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The Small Bottom and Shore Fauna of the Middle and Lower Illinois River and its Connecting Lakes, Chillicothe to Grafton: its Valuation; its Sources of Food Supply; and its Relation to the Fishery

BY

ROBERT E. RICHARDSON

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ERRATA

Page 97, line 17, for first *larval* read *pupal.*
Page 112, in legend, for *jonessi* read *jonesii.*
Page 114, in legend, for *or* read *of.*
Page 125, line 4, for *Bonosa* read *Bonasa.*
Page 131, in legend, for *hirundinaceus* read *hirudinaceus.*
Page 138, last line, for *coccoon* read *cocoon.*
Plate XII, explanation page, next to last line, for *acrivora* read *aerivora.*
Plate XIII, explanation page, next to last line, for *White-grubs* read *White-grub.*
Page 293, Figure 5*a* was reversed in printing, and the two items of the legend should change places.
Page 515, second table, for *Pelocoris femorata* read *Pelocoris femoratus.*

ARTICLE XV.—*The Small Bottom and Shore Fauna of the Middle and Lower Illinois River and its Connecting Lakes, Chillicothe to Grafton: its Valuation; its Sources of Food Supply; and its Relation to the Fishery.* BY ROBERT E. RICHARDSON.

INTRODUCTION

The present paper, so far as it relates particularly to the valuation of the bottom and shore animals, brings together the results of three summer-autumn seasons of dredging operations in the Illinois River and its connecting backwaters, July, 1913, to October, 1915. The work in the river proper and in the wide expansion of its waters known as Peoria Lake included forty cross-sections at intervals ranging from one to about eleven miles, covering the lower one hundred and eighty miles of the river, or about 80 per cent. of the total distance between the mouth and the head of navigation at La Salle; and embraced a total of three hundred and eighty-seven dredge and dipper collections. The dredging operations in the more inclosed bottom-land lakes were mainly confined to those in the middle Illinois valley district of about fifty-nine miles river length between the Copperas Creek and Lagrange dams, in the lakes and other backwaters of which region three hundred and eighty-five dredge and dipper hauls were taken during the three working seasons.

In addition to the collections of the bottom animals for the valuation studies, sieved samples of the mud deposits on the floor of both the river and the lakes were taken in 1913 and 1914 and analyzed for such indications as they might contain of reasons for differences in productivity of different bottom areas. Between March, 1914, and February, 1915, also, standard sanitary chemical analyses of water samples from a limited number of stations in the upper, middle, and lower river were carried on continuously at weekly intervals with a view particularly to obtaining data on the nitrogen load of the waters and on the rate of progress of its nitrification. Such comparisons as are undertaken with plankton production are with reference mainly to data collected in 1909 and 1910, the most recent seasons devoted at all extensively to plankton operations in the region of the river covered by the present paper. Some principal conclusions from the plankton work of these two years in the river and lakes at Havana, as also from the sanitary chemical analyses of 1914-1915, have already been reported upon in papers by Prof. Forbes and the present writer (Forbes and Richardson, 1913; 1919).

Apparatus.—The collection of the bottom fauna was begun in the summer of 1913 with our ordinary iron dredges (modified "Blake" or

"Naturalist's" type (see pages 367, 368), supplemented in some situations where there was unusually soft mud and where the heavier framed iron dredges were inclined to sink too deeply and fill too quickly, with a lighter framed dredge following closely a recent design by Ekman which was intended for quite a different purpose. (See Fig. 3 and 4.)

Although there was no expectation early in the work of making more than a very rough quantitative application of the biological data obtained, all the dredge hauls were, from the first, of a previously determined and recorded length. The introduction into use in the summer of 1914, for work in water under eighteen feet in depth, of the "mud-dipper" (see Fig. 5), an instrument bearing some resemblance to the Walker dipper-dredge as used by Baker (1916, 1918), and the adoption of finer meshed inner bags for it and the dredges, was the means of what appeared to be rather more accurate work that year than in the first season, while at the same time its use in parallel test hauls of different lengths alongside the iron dredges suggested that averaged results from measured drags, under certain limits of length, with either, had a greater quantitative value than we had at first believed. It was found, in brief, that with a 22″ × 6″ front iron dredge we took on the average as many bottom animals by hauling five feet as by hauling ten, and with a 6-inch mud-dipper as many in two feet as in four, but that in hauls under two or five feet, in either case, we got less. As the average 5-foot haul with the dredge was in the neighborhood of ten times the 2-foot drag of the dipper, and the 2-foot dipper haul about five times a quick deep dip of the mud-dipper to a depth of about three inches (approximate area covered, 25 square inches), it was an easy step to the conclusion that on a rough average, if a few apparently aberrant cases be excluded, the most of the 5- to 10-foot dredge hauls might be safely taken to represent an effective drag of about one square yard, and the 2- to 4-foot hauls of the dipper an effective drag of about 0.1 square yard (125 to 130 square inches). Still more recent parallel tests of the dipper alongside a new Petersen self-closing bottom sampler have not served materially to change these conclusions.

The method used for collecting the small weed animals in the zones of densest vegetation (usually in water under four feet deep) was incomplete, taking in only the small fauna within the 0 to 9-inch depth line. A large bucket of known depth and diameter was lowered about the tops of the plants, the stems were cut off underneath, and then the bucket was brought into an upright position quickly; after which the weed-tops were shaken out in the water saved, and that was finally passed through a 120-mesh sieve. Pulling up the weeds entire in water over two and a half feet deep had shown that the attached weed animals, whether snails, insect larvae, or Crustacea, were, in bulk at least, decidedly most abundant nearer the top. And the adoption of the method also followed, by necessity, some unsatisfactory experience in the use of a small 3-legged caisson and pump—which involved the handling of vastly more material

than was practicable, with also an annoying tendency to in-leakage of outside water at the bottom.

Valuation.—The determination to undertake a valuation of the bottom invertebrate populations that come within the feeding horizon of our ordinary bottom-feeding fishes in terms of pounds per acre was made some time after the conclusion of our field work in 1915, and has been carried out on a basis of estimated average-sized specimens of the various species as they ran in a relatively small number of typical midsummer collections weighed after more than a year's preservation in alcohol and formalin. An average correction of 25 per cent. for loss in weight in alcohol (on a base of *body weight only* for Mollusca, and on a base of *gross weight* for other groups) has been made, after a limited number of experimental weights, in the preserved and the fresh state, of a few snails and insect larvae. The final valuation figures, so far as they include insects, their larvae or other immature forms, worms, or Crustacea, represent gross rough weights, but in the case of the Mollusca (Gastropoda, Sphaeriidae, or young Unionidae) represent the body weight only, after deduction of shell weights at rates determined separately for each species by actual weighing. Sponges, Bryozoa, and other smaller incrusting invertebrates are not included in the valuation figures; as are not also crayfish or pearl-button mussels, except the young.

Acknowledgments.—For many of the hydrographical and physical data we are indebted to the U. S. Army Engineers' survey of 1902—1905 (House Document 263, 59th Congress, 1st session, and accompanying charts); as well as to Alvord and Burdick's recent excellent report (1915) on the Illinois River and its bottom-lands; and, in a lesser degree, to the Report of the Legislative Committee on submerged and shore-lands (1911). Thanks are also due Dr. Edward Bartow, Chief of the State Water Survey, for his interested cooperation in obtaining the sanitary chemical analyses of river waters in 1914; and to Prof. S. W. Parr for supervising the analysis of the bottom mud samples taken that year and the year preceding. To Mr. Charles A. Hart is owing a special debt for his assistance in the determination of much of the more unfamiliar biological material of the earlier collections, taken in the preliminary field work of July–September, 1913. Mr. F. C. Baker has contributed both facts and opinions that have made possible rough valuations, for comparison with our own, of the littoral bottom fauna areas of the lower south bay of Oneida Lake, New York, reported upon by him in two very interesting and valuable papers in 1916 and 1918. To these two papers and to Dr. C. G. Joh. Petersen's several recent contributions on the valuation of sea-bottom off the Danish coast (Reports of Danish Biological Station, 1911-1918), I owe not a few ideas which have cast illumination in more or less dark places. The general plan into which the present piece of work is intended to fit, the directing force behind it, and the supply of means and general suggestions as to methods for its execution, have been the work and care for many years of the Chief of the Natural

History Survey, Professor Forbes, without whose aid in these more profoundly important respects the present investigation would doubtless neither have been conceived or carried out in its present scope and form.

Illustrations of Apparatus.—Fig. 1. Iron dredge, showing canvas protector covering posterior bobinet bag, and forward coarse-mesh bag hung backward inside.

Fig. 2. Iron dredge, showing canvas protector rolled back to uncover bobinet bag, and forward coarse-mesh bag pulled out in front of frame.

Fig. 3. Ekman dredge, showing canvas protector covering posterior bobinet bag, and forward coarse-mesh bag hung backward inside; front mud shoes of Ekman design omitted.

Fig. 4. Ekman dredge, disposed as iron dredge in Figure 2.

Fig. 5. Mud-dipper, showing bobinet bag pulled out in front of thimble, and canvas protector in position for drag.

Fig. 6. Apparatus used in 1914 for collecting samples of the thin bottom ooze for study of the composition of the lighter detritus and the microorganisms entering into the food supply of the small bottom animals.

General Summary

It is the purpose of the studies here reported to make an estimate, based on many quantitative collections, of the total store of animal life on and in the bottom sediments of different sections of the middle and lower Illinois River and its bottom-land lakes and on the plants of their shallower, marginal waters, to trace the causes of the wide differences in this respect between river and lakes and between different sections of the stream, to estimate, also quantitativly, the food resources which the bottom muds contain for the animals inhabitating them, and thus to trace in a general way the successive steps by which the organic materials in the muds and waters of the river system are converted into forms available as food for man. This is, in fact, to be regarded as essentially a *soil survey* of these aquatic public properties, for the beds and weedy margins of rivers and lakes are a natural soil of various fertility, of which the animals, mainly univalve mollusks and a few kinds of insect larvae, are the crop, harvested chiefly by fishes, these being harvested in turn by man. From this point of view the *upper* Illinois River is, under present conditions, mainly a mass of plant and animal weeds—forms which occupy the polluted waters to the practical exclusion of everything useful to human kind—but the current of this section carries elements of a normal fertility to the lower reaches of the river, depositing a large part of them finally in the silts and sediments of river and lake in forms available for the nutrition of normal aquatic life, but bearing also an immense quantity to the mouth of the stream where it escapes unutilized into the Mississippi.

The river system below Chillicothe varies enormously in the productiveness of its different parts, the richest of them being the weedy margins

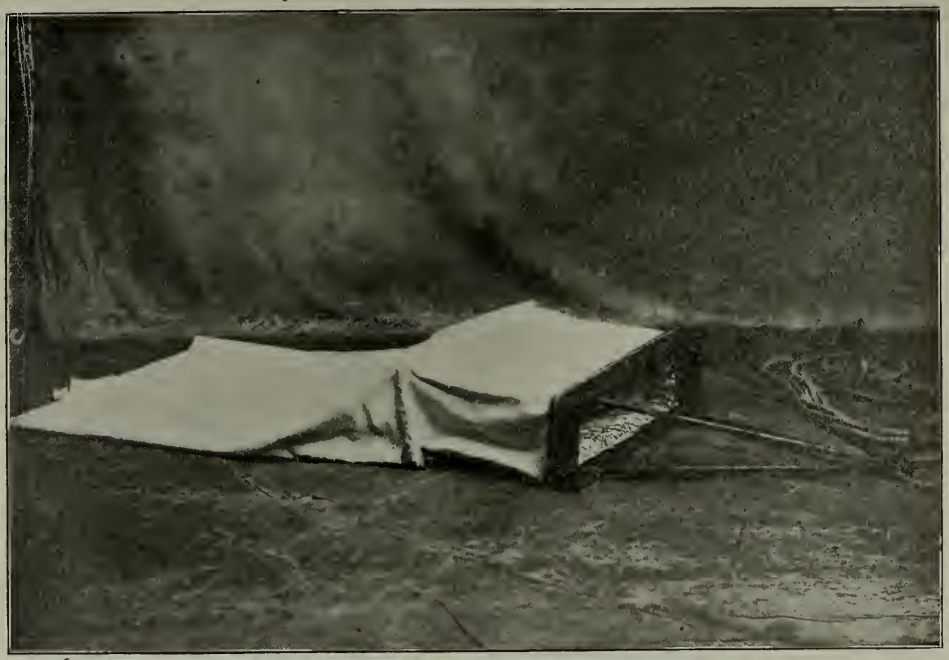

FIG. 1. Iron dredge, showing canvas protector covering posterior bobinet bag, and forward coarse-mesh bag hung backward inside.

FIG. 2. Iron dredge, showing canvas protector rolled back to uncover bobinet bag, and forward coarse-mesh bag pulled out in front of frame.

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of the shallower lakes, and the poorest those sections of the river channel which are swept comparatively bare of sediments by a relatively swift flow. In the river itself much the most abundant product is found where the current is most sluggish, and the bottom sediments are consequently deepest and are most heavily charged with organic materials originally washed into the stream by rains or poured into it by sewers of cities and towns and transformed by oxidation into compounds suitable for the nutrition of clean-water plants and animals.

In a stretch of the river above Havana, which, with its adjacent lakes, is the richest part of the Illinois River system, the inshore and bottom fauna of the lakes averages in weight to the acre about twice as much as that of the river, and it is in the lakes that the fisheries give their highest yield. The bottom soils of the lakes are, indeed, richer in organic matter, as a rule, than are those of the river opposite, and the muds of the marginal waters of these lakes are richer than those of their deeper parts—facts traceable, in part, no doubt, to the more abundant light and higher temperature of the shallower waters and the consequent greater growth of plants whose decay enriches the soil from which they sprang.

At ordinary high-water levels the current of the river from Chillicothe to the mouth varies from one to two miles per hour according to the slope of the bottom, the width of the bed, and the presence or absence of obstructions; and at the highest water it does not much exceed three miles per hour for any important distance. At ordinary midsummer levels the current rate per hour varies in different sections from half a mile to a mile. At lowest water it drops, between Chillicothe and the foot of Peoria Lake, to as little as .29 mile per hour.

Above Havana the bottom, both along the shores and in the channel, is, with some exceptions, a rather deep black mud, but below Havana this shades gradually into hard clay or sand and shells, soft mud failing completely in the channel for long distances. The quantity of inshore vegetation is negligible in the river proper, even in the driest seasons, since the opening of the sanitary canal of the Sanitary District of Chicago in 1900. The bottom-land lakes between Copperas Creek and Lagrange are gradually filling with river silt and a growth of plants. A few have sandy beaches next the eastern bluffs, but the bottoms of all are otherwise of deep black mud, mixed in the shallow water along shore with coarse rotting vegetation. In midsummer the margins of all the deeper lakes, to a depth of four to six feet, are well supplied with vegetation, while the shallower lakes are in many cases weedy over their entire acreage.

From Chillicothe to Lagrange the animal life of both channel and shore waters is almost wholly mollusks (86 to 99 per cent. in collections made), but below Lagrange insect larvae (caddis-worms and May-fly larvae) were more abundant than above in the shore muds, the ratio of mollusks falling to 31 to 65 per cent. In the deeper, opener lakes, mollusks made 77 to 96 per cent. of the collections, and in the shallower, more weedy lakes, 36 to 79 per cent.

Speaking generally, the richest sections of the river floor are those with the least average slope and the slowest current, and therefore with the most abundant sediments. The quantity of the bottom fauna diminishes rapidly down-stream from Chillicothe, averaging 555 pounds to the acre for the upper sixty miles (the weight of the shells of the mollusks being in all cases deducted), 88 pounds for the forty-two and a half miles next following, and 10.4 pounds for the lower seventy-seven miles. The general average for the river channel from Chillicothe to the mouth was 261 pounds per acre. That for Copperas Creek to Lagrange, within which section lay the twelve principal lakes studied, was 705 pounds per acre, and the highest sectional yield was 2,693 pounds per acre between Copperas Creek and Havana. The highest local yield was found in the lower half of this Copperas Creek-Havana section, whose channel product rose to 5,196 pounds per acre. These enormous yields in the stretch above Havana were evidently due, at least in great measure, to the sluggish current and consequent heavy sedimentation and to the great predominance (99 per cent.) of relatively large, thick-shelled snails, edible only by the larger fishes, armed with a powerful crushing apparatus in jaws and throat.

In the muddy section of river above Havana the channel yields approximated or even surpassed those of the shallow waters along shore; but below Havana, where mud is largely replaced by sand, clay, or shells, the channel yields were only 5 to 10 per cent. those of the longshore zone.

Comparing river and lakes between Copperas Creek and Lagrange (59.3 miles) we find that the average bottom yield per acre of twelve lakes examined was about one third that of the river opposite them, but that it was practically the same as the average for the entire river from Chillicothe to the mouth. The deeper lakes with sandy beaches at one side yielded about twice as much per acre as the shallower lakes with mud banks all around.

In the deeper bottom-land lakes surrounded by mud banks, the shore belt, to a depth not exceeding six feet, yielded about three times as much bottom fauna per acre as the deeper open water of these lakes; but in the sand-beach lakes this relation was reversed, the deeper bottom yielding five or six times as much as that within the 6-foot line.

The foregoing statements all apply to the animals living in or on the bottom muds; but in the shallow, *weedy areas* of lakes and backwaters the small invertebrate animals living on and among the weeds greatly exceed both in number and in weight per acre the fauna of the bottom itself, aggregating in many collections made near Havana in 1914, from 1,100, to nearly 2,600 pounds per acre, with an average of 2,118 pounds—quantities to be compared with an average of 255 pounds of *bottom fauna* per acre from the lakes of the same district.

Combining weed and bottom faunas of our collections and applying their joint averages to the entire area of lake and backwater between

Copperas Creek and Havana, we get a yield of 1,447 pounds per acre, to be compared with 705 pounds per acre for the unusually rich sections of the river opposite.

From analyses of the bottom muds of the river channel and estimates of the nitrogen content of total bottom fauna per acre, it appears that the nitrogen in the river sediments is many hundred times the nitrogen content of the flesh of the animals living in them, and that the total dry organic matter in the channel muds is several thousand times the dry weight of this bottom fauna.

Chemical analyses show that the bottom soils of the lakes are richer in organic matter than those of the river opposite them, and that in the lakes themselves the bottom soil is richer near the shore than at the center.

The plankton of the river passing Havana in a year amounts to about 200,000 tons live weight, equivalent to four thousand to ten thousand tons dry weight. This is, roughly, 20 to 50 times the total dry weight of the flesh of the animals of the bottom muds of the lakes from Copperas Creek to the mouth, a distance of 138 miles.

An estimated total of 600,000 tons dry weight of organic matter, suspended and dissolved, passed Chillicothe in 1914. This is 60 to 150 times the dry weight of the plankton that passed Havana in twelve months (1909 and '10), and 3,000 times the dry weight of the total bottom fauna of 1915 from Copperas Creek to the mouth of the river. The dry weight of nitrogen in the above organic matter was sufficient to replace the nitrogen in the plankton of a year from 92 to 232 times.

The plankton per cubic meter of water was greater throughout the year in Thompson Lake than in the river opposite in 1909 and '10, the difference being greatest at times of lowest production (midsummer and winter) in both river and lake.

The river plankton is constantly settling to the bottom to an important degree, as is shown by the composition of the bottom ooze and by the stomach contents of small invertebrates living on and in it. In June, 1914, living, moribund, or recently dead limnetic plankton was more abundant in the upper layers of the ooze than the normal bottom plankton or old organic detritus, as was shown by the food of Sphaeriidae, Trichoptera, and Chironomidae, and it made also an important part of the food of large detritus-eating gastropods (Viviparidae, Pleuroceridae, etc.).

There is a much greater loss of plankton down-stream than can be explained by dilution merely. The falling off in plankton per cubic meter between Havana and Grafton amounted, during nine months of the growing season, to approximately 62 per cent., notwithstanding the normal rate of multiplication of the planktonts as they passed down stream. These losses were greatest when the current was slowest and settling consequently easiest. They were not due to lack of food, because the percentage of nitrogen and the nitrates increased from Havana downward.

In our opinion and that of the most intelligent and observant fishermen, the lakes are the favorite feeding grounds of the larger and more common fishes, and this opinion is supported by the fact that the lakes have a more abundant food supply per acre than the river, and that the heaviest fish-yields come from sections where the ratio of lake areas to river is greatest.

The average weights of the yields of the inshore bottoms of the Illinois River lakes in 1915 were about five times as great per acre as those of the glacial lakes of northeastern Illinois in 1916, and the composition of the faunas was also widely different, mollusks occurring in the latter in relatively insignificant proportion and being nearly all of the smaller species. The weed faunas of Fox and Pistakee lakes were almost wholly made up of small crustaceans and insects, the former predominating, although the total weights were not very much less than those of the Illinois system.

Hydrography and Bottom Fauna, Illinois River, Chillicothe to Grafton, July–October, 1915

(a) Chillicothe to Foot of Peoria Lake (18.5 Miles)

Hydrography.—If the Illinois River is a sluggish stream considered as a whole, in comparison with most other important American rivers, the grand prize for local leisureliness of movement belongs to the short stretch between Chillicothe and the lower end of Peoria Lake, where, in March, 1903, *at a flood stage* of approximately eighteen feet above old low-water marks at Peoria, it took ball floats twenty-nine hours and fifty-nine minutes to make a total distance of 17.7 miles, the average rate per minute being 51.94 feet, and per hour, 0.59 mile. At a gage of nine feet, Peoria, which is almost exactly the mean level of the month of August, 1914, and represents the lowest water in this part of the river in the past seven years, these rates would be reduced to 25.97 feet per minute or 0.29 mile per hour—a total time in transit of fifty-nine hours and fifty-eight minutes for the 17.7 miles.

These velocities compare with an average of 229.47 feet per minute or 2.60 miles per hour at a corresponding flood gage for the 33.9 miles Morris—Utica; and with 115.43 feet per minute or 1.31 miles per hour for the 229.6 miles between Utica and Grafton. Above Peoria only the 12-mile section Henry—Hennepin has a current approaching the low figures found between Chillicothe and Peoria. In the other short reaches above Peoria, and in all below Peoria except the section of 8 miles between Liverpool and Havana (with 66.00 feet per minute, or 0.75 mile per hour), average flood velocities are over 100 feet per minute (1 mile per hour). The greatest velocities below Utica occur in the 9.8 miles between Peoria and Pekin (with 191.64 feet per minute or 2.17 miles per hour); and in the reaches below Florence, which have over 180 feet per minute, or more than 2 miles per hour.

TABLE OF APPROXIMATE AVERAGE VELOCITIES, ILLINOIS RIVER

This table is based on float records of J. L. Van Ornum, as published in Water Supply Paper No. 194, U. S. Geological Survey, 1907, pp. 17-18.

(The gage at Peoria averaged about eighteen feet during the tests. The figures for nine feet are one half the 18-foot figures, various measurements by the U. S. Geological Survey and others showing about 50 per cent. decrease in velocity between approximately these gages at Peoria and corresponding gages at other stations.)

Reach	Miles	Gage, 18 ft., Peoria		Gage, 9 ft., Peoria	
		Ft. per min.	Mi. per hour	Ft. per min.	Mi. per hour
Morris to Utica	33.9	229.47	2.60	114.73	1.30
Utica to Grafton	229.6	115.43	1.31	57.61	0.65
Utica to Hennepin	21.6	137.73	1.56	68.86	0.78
Hennepin to Henry	12.0	67.33	0.76	33.66	0.38
Henry to Chillicothe	15.5	103.98	1.18	51.99	0.59
Chillicothe to foot Main St., Peoria	17.7	51.94	0.59	25.97	0.29
Foot Main St., Peoria, to Pekin	9.8	191.64	2.17	95.82	1.08
Pekin to Banner*	14.3	114.40	1.30	57.20	0.65
Banner to Liverpool	10.7	105.01	1.19	52.50	0.59
Liverpool to Havana	8.0	66.00	0.75	33.00	0.37
Havana to Beardstown	31.5	129.13	1.46	64.56	0.73
Beardstown to Lagrange dam	11.0	152.04	1.72	76.02	0.86
Lagrange to Florence	21.9	146.92	1.66	73.47	0.83
Florence to Kampsville dam	24.2	183.85	2.08	91.92	1.04
Kampsville dam to Grafton	31.4	186.91	2.12	93.45	1.06

Differences in velocity within the 18 miles between Chillicothe and Peoria are indirectly shown in the next table in figures for elevation of water surface at the low gage of 1901. In more than thirteen out of the eighteen miles the decline was too small to be measured; for one-half mile there was an average slope of over two inches; and in the lower four and a half miles a slope of about three fourths of an inch per mile.

Widths between banks in this section of the river at the low water of 1901 ranged from 439 feet just below Chillicothe to more than a mile in the widest parts of the expanded portion known as Peoria Lake, which occupies more than seventeen of the eighteen and a half miles. If we figure the normal area of the river proper per mile throughout the reach at the 1901 low water at a mean (80.0 acres per mile) between the

* About 2 miles above Copperas Creek dam.

DECLINE IN ELEVATION OF LOW-WATER SURFACE, 1901

Reach	Interval miles	Av. slope (inches) per mile
Chillicothe—foot Peoria Lake	18.3	0.26
Chillicothe (mile 180.5)—Mile 171.0*	9.5	Not measurable
Mile 171.0—170.5	0.5	2.40
Mile 170.5—166.9	3.6	Not measurable
Mile 166.9—165.5	1.4	0.85
Mile 165.5—163.8	1.7	0.70
Mile 163.8—162.2 (foot of lake)	1.6	0.75

averages just above and just below Peoria Lake, this is found to be less than one fourth of the actual average continuous area flooded in each mile (379.9 acres); or, in other words, the river was on the average throughout this eighteen-mile section at those levels more than four times normal width. The ex-river or lake acreage per mile at the low water of 1901 figured in this way (379.9—80.0=299.9 acres per mile) in fact exceeded that found for any other sections of the river except two, viz., the 16.8 miles between Copperas Creek dam and Havana and the 42.5 miles between Havana and the Lagrange dam.

LAKE AND POND ACREAGE, LOW WATER, 1901
(AS IN VALLEY BEFORE LEVEES)

Reach	Interval miles	Lake and pond acreage per mile
Chillicothe to foot Peoria Lake	18.5	299.9
Foot Peoria Lake to Pekin	9.0	113.6
Pekin to Copperas Creek dam	16.2	219.0
Copperas Creek dam to Havana	16.8	472.1
Havana to Lagrange dam	42.5	382.4
Lagrange dam to Florence	21.9	219.6
Florence to Kampsville dam	24.2	180.0
Kampsville dam to Grafton	31.4	86.9

Depths in the river channel between Chillicothe and the foot of Chillicothe Island (0.9 mile below Chillicothe, the point where the expansion into the wide waters of Peoria Lake begins) were 22.5 to 24 feet at the low water of 1901, and have been about four and a half feet more than those figures at recent low gages. The channel through the lake at the low water of 1901 varied in depth from about seven to a little over twenty feet; and at recent low levels from over eleven to over twenty-four feet.

* Mile figures represent miles above Grafton.

WIDTHS AND DEPTHS, CHILLICOTHE TO FOOT OF PEORIA LAKE, LOW WATER, 1901

Miles above Grafton	Station	Width, ft.	Depth, ft. max.
	Unwidened river—		
180.2	500 yds. below boat-landing, Chillicothe	494	24.0
179.6	Foot Chillicothe Island	439	22.5
	Upper lake—		
178.4	Head Peoria Lake, one half mile above Rome	1,000	17.0
177.9	Rome	3,960	14.0
175.5	One and a half miles above Spring Bay	5,463	7.5
	Middle lake—		
173.4	500 yds. below Spring Bay	1,024	10.8
173.1	About half a mile below Spring Bay	1,850	16.8
169.5	Three miles above Peoria Narrows	5,627	10.0
168.0	One and a half miles above Peoria Narrows	5,280	20.1
	Lower lake—		
166.5	Peoria Narrows (above bridge)	658	15.5
164.2	Opposite work-house	3,922	12.5
162.5	Opposite foot Main St.	1,760	10.8
162.2	Lower wagon-bridge	870	5.1

As we should expect, the upper soil strata in the channel throughout most of this section consist of dark-colored mud of a good depth. The mud layer is four feet deep in the channel at Chillicothe, and ranges from 7.5 to over 22 feet in depth at boring stations (U. S. Engineers, 1902–05) in the upper, middle, and lower lakes, if we except a stretch of less than two miles in and immediately below Peoria Narrows. At the Narrows and just below, cap-rock comes to within four or five feet of the surface, and the upper stratum consists of a well-packed mixture of mud and shells. This is followed for about a mile by a deep upper layer of dirty sand and shells, after which (between Mile 165 and Mile 164) deep mud begins again and is continued to the foot of the lake. At the foot of the lake rock comes again to within eight feet of the surface, and the floor of the river just above the mouth of Farm Creek is formed by gravel fifteen feet deep—hard bottom of sand or sand and shells continuing from this point all the way to Pekin.

Findings regarding bottom deposits at our collecting stations in 1915 agree very well, as far as they go, with the data from the government borings, and are satisfactorily consistent with such data as we have on slope and velocity. The mud brought up by the dredges, except at Peoria Narrows, was all very dark in color, and the recent origin of much of it was indicated by the softness of the upper layers. Measurements

of the "depth to hard bottom"* ran from thirty-six to seventy-two inches at stations between Rome and the foot of Main St., Peoria. At the Narrows the mud was harder, lighter in color, and was mixed with old dead shells and thickly carpeted with sponges and Bryozoa.

Depth (of Softer Mud) to Hard Bottom at Channel Stations

Miles above Grafton	Station	Inches
180.5	Chillicothe	3
177.2	One mile below Rome	72
175.5	Peoria Narrows	Hard bottom
172.3	Opposite Mossville	48
166.5	One and a half miles above Spring Bay	36
162.7	Opposite foot Main St.	36

The elevation of the bottom of the river channel eighteen miles south of Chillicothe, instead of being lower, is actually more than eighteen feet higher than the plane of greatest depth opposite Chillicothe; more than fourteen feet above the bottom plane of the deepest part of Peoria Lake above the Narrows; and more than two feet *higher* than the *highest* point in the channel bottom between Chillicothe and the foot of the lake. I think we must suppose that the way out of Peoria Lake was once much more open, and that the action of Farm Creek has been largely responsible for building up the high bar that now dams up the entrance into the Pekin reach. The nearness to the surface of rock between Peoria Narrows and Wesley would, however, have prevented in any case the excavation of a fast and deep channel through the Chillicothe-Peoria section.

Because of the very shallow gradient, and the great expansion of the river between Chillicothe and Peoria, the shallower backwater in most of the distance, though not separable from the river channel by any distinct boundary, resembles more nearly the larger inclosed bottom-land lakes than ordinary river littoral. Except for a very short distance at and near Peoria Narrows, the land to the eastward of the channel is low, the banks are all of mud, and the soft bottom sediments very dark in color. Within the 3-foot line on this side the bottom muds contain more decayed vegetable matter than further out, and there is a good deal of living vegetation (principally Potamogetons and Ceratophyllum) during the dry season. On the west side of the channel, sand or gravel or hard mud bottom is found for considerable distances out to a depth of three to seven feet wherever the channel closely approaches the bluff. Opposite Mossville, where the channel is east of the middle of the lake, the 1–3- and 4–7-foot zones on the west side are very similar in midsummer to those on the east side first described. Except for a short dis-

* Made by forcing a 2 × 2-inch pole, square across the end, as deeply into the mud as a strong man could with both hands.

tance at this place, such vegetation as grows on the west side is usually only a thin fringe next the rather steep bank. Outside the 4-foot line Peoria Lake has recently been almost entirely free of vegetation, even at the lowest gages, and it is consequently much more subject to roiling by winds than the narrower and weedier lakes near Havana.

The Bottom Fauna.—Collections of the small bottom animals, with dredges and mud-dipper, were made in the channel July 26 to August 19, 1915, at four stations in the mud-section between Chillicothe and Peoria Narrows; in the hard mud at Peoria Narrows; and in the mud opposite the steamboat landing at Peoria.

CHANNEL COLLECTIONS, CHILLICOTHE TO PEORIA LAKE, 1915

Miles above Grafton	Station	No. collections July—August, 1915	Depth adjusted to gage July—October, 1910—1914	
180.5	Chillicothe	2	28	Deep, narrow river
177.2	One mile below Rome	1	12	
175.5	One and a half miles above Spring Bay	3	11	Upper lake, channel
172.3	Opposite Mossville	2	19	Middle lake, channel
166.5	Peoria Narrows	3	19	
162.7	Opposite Eagle Packet landing	4	15	Lower lake, channel
Total channel collections.....		15		

The average number of bottom animals in a square yard of channel bottom, if we except the Peoria Narrows station (which represents a very limited area with hard bottom), compared favorably (at 235 per sq. yd.) with the figures from some other short reaches between Peoria and Havana, but was under the average for the 60.5 miles (416 per sq. yd.), and was far below the figure for the very rich section of eight miles just above Havana (1,469 per sq. yd.). In all the collections Mollusca (Gastropoda and Sphaeriidae) were much more numerous than insects, worms, and small Crustacea; and the larger Gastropoda (Viviparidae and Pleuroceridae) were usually more abundant than the Sphaeriidae and smaller Gastropoda (Amnicolidae, etc.).

BOTTOM FAUNA, CHANNEL, 1915
NUMBERS PER SQUARE YARD, AVERAGE

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total	Collections
Chillicothe—Mossville	88.2	143.7	26.6	258.5	8
At Peoria Narrows	23.2	1.0	13.3	37.5	3
Peoria Narrows to foot of Peoria Lake	134.5	5.0	48.0	187.5	4
Average (excepting collections at Narrows)				234.8	12

The average valuation of the channel bottom fauna in pounds per acre (shells of Mollusca deducted) in this section (285.9 pounds, with the Peoria Narrows station included; 345.1 pounds, with Peoria Narrows omitted) was better than the average (239 pounds) for the 43.7 miles between Chillicothe and the Copperas Creek dam, but was less than one tenth of the channel average between Copperas Creek dam and Havana (3,029 pounds per acre), and less than one twentieth of the average valuation for the eight miles between Liverpool and Havana in 1915 (5,180 pounds per acre). The great bulk of the collections, by weight (85 per cent.), was made up of the larger snails (Viviparidae and Pleuroceridae), and these families together with the Sphaeriidae and smaller Gastropoda accounted for about 98 per cent. of the average poundage taken.

BOTTOM FAUNA, CHANNEL, 1915
POUNDS PER ACRE, AVERAGE

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total	Collections
Chillicothe to Mossville	244.1	70.4	3.1	317.6	8
At Peoria Narrows	46.3	0.5	2.1	48.9	3
Peoria Narrows to foot of Peoria Lake	391.6	3.1	5.6	400.3	4
Average (including Narrows)	243.8	38.4	3.5	285.9	15
Per cent. of total	85.2	13.4	1.4		
Average (excluding Narrows)	293.2	47.8	3.9	345.1	12
Per cent. of total	84.9	14.0	1.1		

A total of thirty collections in the shallower areas between Chillicothe and the foot of Peoria Lake were taken with the mud-dipper in 1915; ten within the 4-foot line, and twenty between the 4- and 7-foot lines (depths adjusted to gage July–October, 1910–1914).

SHORE COLLECTIONS, CHILLICOTHE TO FOOT OF PEORIA LAKE, 1915

Miles above Grafton	Station	1- to 3-foot zone	4- to 7-foot zone
		Collections	Collections
180.5	Chillicothe	...	2
177.2	One mile below Rome	3	5
175.5	One and a half miles above Spring Bay	2	5
172.3	Opposite Mossville	4	4
162.7	Opposite Eagle Packet Landing	1	4
Total collections		10	20

Average numbers per square yard in the 1- to 3-foot zone (233.7) were about the same as in the channel opposite (234.8), but were appreciably under those found in the 4- to 7-foot zone (314.6). Both in the 1- to 3-foot and the 4- to 7-foot zones there were proportionally much larger numbers of Sphaeriidae and of insects, worms, and small Crustacea than were present in corresponding channel collections.

BOTTOM FAUNA

1- TO 3-FOOT ZONE, 1915

NUMBERS PER SQUARE YARD, AVERAGE

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total	Collections
Chillicothe to Mossville	7.7	148.6	76.3	232.6	9
Peoria Narrows to foot of Peoria Lake	50.0	70.0	120.0	240.0	1
Average	....	....	....	236.3	10

The average *poundage* per acre of bottom animals in the 1- to 3-foot zone* (108.4 pounds) was less than one third the average channel valua-

* No collections at Peoria Narrows.

4- to 7-foot Zone, 1915
NUMBERS PER SQUARE YARD, AVERAGE

Chillicothe to Mossville	30.8	200.3	68.7	299.8	16
Peoria Narrows to foot of Peoria Lake	53.0	167.5	52.5	373.5	4
Average	....	....	....	314.4	20

tion opposite (345.1 pounds), although *numbers* per unit area were about the same, the Sphaeriidae and smaller Gastropoda making up over 50 per cent. of the average in weight and the insect larvae, worms, and Crustacea over 7 per cent. as compared with much smaller ratios in the channel collections.

The average 4- to 7-foot zone* valuation (259.4 pounds per acre) was about two and a half times that of the 1- to 3-foot zone (108.4 pounds), and about 25 per cent. under the average channel valuation (345.1 pounds). The larger snails (Viviparidae principally), while not relatively so abundant as in the channel collections, made up a noticeably larger portion (64.6 per cent.) of the totals by weight than was the case in the 1- to 3-foot zone.

Tables summarizing these comparisons of the channel and shore zone averages follow. Further details concerning separate species and families included in the valuations are found in the detailed tables at end.

Bottom Fauna, Chillicothe to Foot of Peoria Lake,* 1915
Summary

	Channel, 12 collections	4- to 7-foot zone, 20 collections	1- to 3-foot zone, 10 collections
Average number per square yard	234.8	314.6	233.7
Average pounds per acre	345.1	259.4	108.4
Per cent. (by weight) Viviparidae and Pleuroceridae	84.9	64.6	41.3
Per cent. (by weight) Sphaeriidae and small Gastropoda	14.0	30.9	51.6
Per cent. (by weight) Insects, worms, Crustacea	1.1	4.5	7.1

* No collections at Peoria Narrows.
* Channel collections at Peoria Narrows omitted. No collections taken in 1- to 3-foot or 4- to 7-foot zone at that station.

BOTTOM FAUNA

1- TO 3-FOOT ZONE, 1915

POUNDS PER ACRE

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total	Collections	Channel total for comparison	Collections
Chillicothe to Mossville	30.1	61.2	7.9	99.2	9	317.6	8
Peoria Narrows to foot of Peoria Lake	174.0	9.8	7.4	191.2	1	400.3	4
Average	44.5	56.0	7.8	108.4	10	345.1	12
Per cent. of total	41.3	51.6	7.1				

4- TO 7-FOOT ZONE, 1915

POUNDS PER ACRE

Chillicothe to Mossville	97.4	86.7	13.3	197.4	16	317.6	8
Peoria Narrows to foot of Peoria Lake	446.3	55.5	5.8	507.6	4	400.3	4
Average	167.1	80.4	11.8	259.4	20	345.1	12
Per cent. of total	64.6	30.9	4.5				

(b) Foot of Peoria Lake to Pekin (9 Miles)

Hydrography.—After passing over the high bar above the mouth of Farm Creek (foot of Peoria Lake) the river follows a comparatively swift and narrow channel to Pekin, the average velocity at a flood gage of eighteen feet, Peoria, being 191.64* feet per minute for the 9.8 miles between the foot of Main St. and the wagon bridge at Pekin, and the width (at low water of 1901) usually under six hundred feet. The average slope of the water surface at the low levels of 1901 was two inches per mile, and 4.36 inches per mile at the high water of March, 1904. These average slopes and velocities are much greater than are met with in any other considerable section of channel in the one hundred and twenty-five miles between Chillicothe and Florence, and are four to seven times the figures for the 18.5 miles between Chillicothe and the foot of Peoria Lake.

Decline in Elevation of Water Surface

Reach	Stage of river	Interval miles	Av. slope inches per mile
Foot of Peoria Lake to Pekin	Low water 1901	9.2	2.00
"	Flood stage Mar. 15, 1903	9.2	3.45
"	Flood stage Mar. 31, 1904	9.2	4.36
Chillicothe to foot Peoria Lake	Low water 1901	18.3	0.26
"	Flood stage Mar. 31, 1904	18.3	0.64

The channel floor is sand and shells, nearly denuded of mud, for most of the nine miles. At our 1915 collecting stations between Wesley and Pekin the bottom was hard, but opposite Pekin the hard bottom was overlaid with a very thin covering of soft silt. Between the 4- and 7-foot lines at Wesley in 1915 hard gravel bottom washed clean of mud was found both on the east and west sides. At the shore stations below the wagon bridge at Pekin six inches of soft mud was found on the west side and 12 to 36 inches on the east. Shore vegetation, except an occasional narrow fringe at the bank edge, is wanting.

At the low water of 1901 the bank to bank width of the river between Peoria and Pekin was usually between 400 and 600 feet, only a very short stretch just below the mouth of Farm Creek much exceeding 600. Depths in the wider and shallower stretches ranged from 7 to 8½ feet; and in the deeper and narrower ones between 10 and 13 feet. Average depths at recent low levels (gage of July–October, 1910–1914) have been about 3½ feet more than these figures. The connecting lake

* Table, p. 377.

acreage (113.6 acres per mile at the low water of 1901) is little more than a third of that which occurs between Chillicothe and the foot of Peoria Lake (299.9 acres per mile); and is under the rating of any other section of the river between Chillicothe and Kampsville.*

WIDTHS AND DEPTHS, FOOT OF PEORIA LAKE TO PEKIN, LOW WATER, 1901

Miles above Grafton	Station	Width, ft.	Depth ft. max.
161.9	50 yds. below mouth Farm Cr.	347	8.1
160.7	P. & P. U. R.R. bridge.....	915	6.6
159.9		640	11.8
159.0	100 yds. below Wesley.....	402	8.3
158.0	.....	514	7.5
157.0	.....	586	7.5
156.0	.....	640	7.2
155.0	.....	515	8.5
153.9	.....	439	12.4
153.3	.....	475	10.3
153.0	Pekin, at wagon bridge.....	...	11.2

Bottom Fauna.—The bottom collections made in cross-sections at Wesley and Pekin in 1915 included four channel hauls and four hauls in the 4–7-foot zone. In neither depth zone was a fauna indicated quite so rich as that of the channel and shore zones between Peoria and Chillicothe, the average channel poundage amounting to 253.8 lbs. per acre, and that of the 4–7-foot zones to only 206.3 lbs.

Larvae of caddis-flies (principally Hydropsyche sp.) were decidedly more abundant in the swifter stretches of channel between Peoria and

BOTTOM FAUNA, CHANNEL, WESLEY TO PEKIN, 1915

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard. Average	87.7	16.7	129.0	233.4 4 collections
Pounds per acre, av.	224.6	8.3	20.9	253.8 4 collections
Per cent. of total, (By weight)	88.6%	3.2%	8.2%	

* See table, p. 378.

Pekin than above Peoria, and the Sphaeriidae less so. The larger Gastropoda (Viviparidae and Pleuroceridae) made up about the same percentage of the average weight of collections as above Peoria (88.6%). In the 4–7-foot zone the Sphaeriidae showed the heaviest poundages (66.2% of totals), and the insect larvae and the larger snails were relatively much less abundant than in channel collections.

BOTTOM FAUNA, 4—7-FOOT ZONE, WESLEY TO PEKIN, 1915, AVERAGE

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard	20.0	272.5	56.5	349.0 4 collections
Pounds per acre	60.0	136.7	9.6	206.3 4 collections
Per cent. of total, (By weight)	29.2%	66.2%	4.6%	

(c) PEKIN TO COPPERAS CREEK DAM (16.2 MILES)

Hydrography.—Following the swift run from the foot of Peoria Lake to Pekin, where the low-water slope in 1901 was 2.00 inches per mile, the effect of the dam at Copperas Creek became very distinct below Pekin at those low levels, and the average slope of water surface between Pekin and the dam fell to 0.14 inch per mile. Although this average low-water decline is not much more than half that between Chillicothe and the foot of Peoria Lake (0.26 inch per mile for 18.2 miles), at ordinary spring flood-levels the slope rate is multiplied ten times or more (1.40 inches per mile at gage 18 ft., Peoria), and the average flood velocity (114.40 feet per minute at gage 18 ft., Peoria) rises to a figure more than double that between Chillicothe and Peoria.*

This circumstance—a consequence of the fact that at flood stages the sweep of the current tends to follow the old lines of slope of water surface as they existed before the low-crested dam was put in—accounts for the generally well-scoured channel floor that we find throughout this reach of 16.2 miles, not even excepting its lowermost portion just above the dam.

The only important stretch of soft mud bottom in the channel in the 16 miles is the deposit occupying less than a mile of channel length just above the mouth of the Mackinaw. With the exception of that and of about a mile of dirty sand which ends a mile above the dam, the gov-

* Table, p. 377.

DECLINE IN ELEVATION OF WATER SURFACE

Reach	Stage of river	Interval miles	Av. slope inches per mile
Pekin to Copperas Creek dam (above)	Low water 1901	16.2	0.14
Pekin to Copperas Creek dam (above)	Flood stage Mar. 15, 1903	16.2	1.36
Pekin to Copperas Creek dam (above)	Flood stage Mar. 31, 1904	16.2	1.43

ernment borings of 1902–1905 showed hard bottom at all channel stations, the upper layer of sand, gravel, or sand and shells having depths of from five to twenty-nine feet. In the shore zones within the 7-foot line mud bottom was found by us in 1915 at all the collecting stations. There is no shore vegetation worth mentioning in the 16 miles.

Between Pekin and Copperas Creek dam at the 1901 low levels, bank to bank widths averaged rather greater than in the Peoria-Pekin section, being usually over 600 feet, and for short distances 700 feet and over. The greatest depths at these levels were under 15 feet, and in a

WIDTHS AND DEPTHS, PEKIN TO COPPERAS CREEK DAM, LOW WATER, 1901

Miles above Grafton	Station	Width, ft.	Depth, ft. max.
153.0	Pekin at wagon bridge	...	11.2
152.8	.....	695	13.0
152.5	.....	...	7.1
151.7	.....	750	10.2
150.5	.....	440	11.0
149.9	.....	677	8.6
149.3	.....	384	14.1
149.0	.....	600	9.0
147.9	.....	610	12.6
146.8	.....	695	7.4
145.6	Kingston	700	8.7
145.2	.....	549	14.7
144.6	.....	732	7.0
143.9	.....	622	8.4
142.9	.....	586	8.3
141.3	.....	530	11.6
139.0	.....	550	8.4
138.3	.....	586	14.5
137.7	.....	570	9.3
137.2	.....	677	10.4
136.95	.....	549	11.0
136.8	Dam		

large part of the section ranged between 7 and 9 feet. Recent maximum low-water depths have been mostly 2 to 3½ feet more than these. The connecting lake and pond acreage in this section at the low levels of 1901 (219.0 acres per mile) was about twice that between Peoria and Pekin per mile of river length, but was not much more than two thirds that between Chillicothe and the foot of Peoria Lake, and was less than half that between Copperas dam and Havana.*

Bottom Fauna.—A total of 14 channel collections and 16 shore collections were made between Pekin and the dam in 1915 at stations as shown below.

Miles above Grafton	Station	Channel	4—7-ft. zone	1—3-ft. zone
151.5	1½ miles below Pekin	2	2	
145.6	Opposite Kingston	6	3	3
141.9	Opposite Spring Lake canal	4	4	4
136.8	100 yards above dam	2		
	Total	14	9	7

The average valuation figure for the channel fauna in the section (144.8 lbs. per acre) was lower than in any other important stretch of channel between Chillicothe and Havana. The weight of the average channel collection was not far from equally divided between the Sphaeriidae and the larger Gastropoda, the first contributing 43.7%, the

Bottom Fauna, Channel, Pekin to Copperas Creek Dam, 1915

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	28.8	126.9	49.8	205.5 14 collections
Pounds per acre, Average	73.3	63.4	8.1	144.8 14 collections
Per cent. of total, (By weight)	50.6%	43.7%	5.7%	

* Table, p. 378.

latter 50.6%. The insects, worms, and small Crustacea made up the remaining 5.7%, the greater part of which was composed of the larvae of the commoner channel caddis-flies.

In the shore zones both numbers and weight valuations were conspicuously higher than in the channel, the average poundage in the 4–7-foot zone being 695 per acre and that in the 1–3-foot zone 391. Contrary to the rule found usually to hold good in the river, the larger Gastropoda (Viviparidae principally) here showed larger poundages and much larger percentages of valuation totals (74 to 91%) both in the 1–3- and 4–7-foot zones than did the Sphaeriidae. The insects, worms, and Crustacea contributed less than one per cent. of the average poundage figures in the 4–7-foot zone. In the hauls taken inside the four-foot line, leeches and chironomid larvae were especially abundant, and these with a few worms and small Crustacea added, made up over 8% of the weight of the average haul.

Bottom Fauna, 4—7-ft. Zone, Pekin to Copperas Creek Dam, 1915

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	177.6	104.0	34.4	316.0 9 collections
Pounds per acre, Average	638.0	52.4	5.1	695.5 9 collections
Per cent. of total, (By weight)	91.7%	7.5%	0.8%	

Bottom Fauna, 1—3-ft. Zone, Pekin to Copperas Creek Dam, 1915

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	108.4	135.7	116.8	360.9
Pounds per acre, Average	292.4	67.8	31.2	391.4
Per cent. of total, (By weight)	74.7%	17.0%	8.3%	

(d) Copperas Creek Dam to Havana (16.8 Miles)

Hydrography.—One is at first surprised to find that although at the low water of 1901 there was a decidedly greater decline in elevation of water surface between the foot of the dam at Copperas Creek and Havana *(0.78* inch per mile for 16.8 miles) than between Pekin and the head of the dam (*0.14* inch per mile for 16.2 miles), average flood velocities in the section below the dam are less than in the section of similar length above it. The average velocity at a gage of 18 feet, Peoria, March, 1903, was *83.81* feet per minute between Banner—about 2 miles above the dam—and Havana; and was *114.40* feet per minute between Pekin and Banner. The average slope of high water surface, however, is in close correspondence with these flood velocities—equaling 1.43 inches per mile between Pekin and the dam, as compared with 1.18 inches per mile between the dam and Havana at a gage of 22.6 feet, Peoria, March 31, 1904; and 1.36 inches per mile between Pekin and the dam, compared with 1.11 inches between the dam and Havana at a gage of 19.0 feet in March, 1903. As the low flood velocities through Peoria Lake are a joint consequence of the high bar above the mouth of Farm Creek and the unusual opportunity for expansion in the broad and low flats above it, the retardation of the flood current between Copperas Creek dam and Havana may be explained also as due jointly to the increased impounding area in this section* and to the high mud bar, superimposed upon an older sand bar, which attains its summit about a mile above the mouth of Spoon River. The top of this bar has an elevation only 0.6 foot below the level of the channel floor just below the dam at Copperas Creek, and is 13.8 feet higher than the deepest part of the channel between Liverpool and Havana. The artificial pool behind the dam at Copperas Creek, on the other hand, lies toward the lower end of a stretch of river with relatively steep natural slope, and at the higher gages the flood water moving through that section tends to follow the old slope-lines of water surface as they existed in the years antedating the construction of the dam.

Quite consistently with what has just been noted, both at flood stages and at the 1901 low levels, average slope and current are appreciably greater in the first than in the second half of the 16.8 miles below the dam, the average velocity (66.00 feet per minute) in the eight miles immediately above the Havana bar at a flood gage of 18 feet, Peoria, being in fact not much more than half that in the first eight miles (105.01 feet) and less than that of any other considerable reach of channel in the whole river below Peoria.

In the first seven miles of channel below Copperas Creek dam the upper bottom stratum as shown by the government borings of 1902–1905 was sand and shells or plain sand to a depth of 4 to 21 feet for the greater part of the distance; though dirty sand or sand and shells occurred at a few of the boring stations and was found by us just above

* Table, p. 378.

DECLINE IN ELEVATION OF WATER SURFACE; AND FLOOD VELOCITY

Reach	Interval miles	Average slope—inches per mile			Flood velocity (average feet per minute., gage 18 ft., Peoria)
		Low water 1901	Flood gage Mar. 15, 1903	Flood gage Mar. 31, 1904	
Copperas Creek dam to Havana	16.8	0.78	1.11	1.18	83.81 (18.7 miles)*
Copperas Creek dam to 1 mile above Liverpool	7.8	1.07	....	....	105.01 (10.7 miles)*
1 mile above Liverpool to Havana	9.0	0.53	....	....	66.00 (8.0 miles)*
Pekin to Copperas Creek dam	16.2	0.14	1.36	1.43	114.40 (14.3 miles)*

* Nearest corresponding velocity-reaches (Van Ornum float tests, March, 1903) stop opposite Banner, instead of at Copperas Creek dam.

and just below Senate Island in 1915. In the nine miles of deeper channel between Mile 129 (1 mile above Liverpool) and Havana, the bottom is uniformly mud. The depth of the mud layer is nearly everywhere more than 8 feet, and in extreme instances 13 to 17 feet. The thickness of the mud stratum diminishes to about 7 feet opposite Havana, and a quarter mile farther south the mud quite gives way to a layer of mud and shells, which description of bottom continues nearly uninterrupted for the next 14 or 15 miles. The bottom soils found in the shore zones between Havana and Copperas Creek in 1915 were dark-colored soft mud throughout the 16.8 miles.

Between the dam and Liverpool, bank to bank widths at the low water of 1901 were much as between Pekin and Copperas Creek—usually 550 to around 700 feet; while the greatest depths were under 12 feet. Below Liverpool the river narrows and deepens decidedly, as far as Mile 122.4—the beginning of the expansion formerly known as Havana Lake. In this six miles, widths at the 1901 low levels ranged from 329 to about 500 feet, and depths from 14 to 21 feet. Opposite Havana, for a distance less than half a mile above the mouth of Spoon River, the wide water spread over the Havana bar (Havana Lake) showed an extreme width in the summer of 1901 of about 1,300 feet; while maximum channel depths in the 3 miles above Mile 121 (1 mile above Havana) tapered off southward from more than sixteen to about seven feet. Recent extreme depths at midsummer low gages in the lower half of this reach have ranged from 4 to 5 feet more than the low-water depths given.

Widths and Depths, Copperas Creek Dam to Havana, Low Water, 1901

Miles above Grafton	Station	Width, ft.	Depth, ft. max.
136.6	500 yards below dam.....	677	7.5
136.0	.....	695	7.7
134.3	.....	475	8.6
133.0	.....	586	8.3
132.5	1 mile below foot Senate Island	549	11.8
129.8	.....	603	10.0
129.0	1 mile above Liverpool.....	586	10.8
128.5	.....	528	11.6
128.0	Liverpool	439	14.6
126.9	.....	439	17.0
126.5	.....	...	16.7
126.0	.....	402	14.0
125.7	.....	...	19.0
125.4	.....	340	17.0
125.0	5 miles above Havana.....	329	21.0
124.0	.....	457	15.7
123.0	Middle of "Hogfat Bend".....	475	16.3
122.4	.....	586	10.8
121.0	Upper end "Havana Lake".....	1,299	7.0
120.0	C. P. St. L. Piers, Havana.....	514	12.2

Connecting lake-acreage per mile of river-length between Copperas Creek dam and Havana at the low gages of 1901 largely exceeded that in any other section of river above or below, the figure of 472.1 acres per mile being 57 per cent. more than between Chillicothe and the foot of Peoria Lake and 23 per cent. more than between Havana and the Lagrange dam—the two other reaches with the highest ratings. (Table, p. 378.)

Though the eight or nine mile stretch of river just above Havana has had more shore vegetation at recent summer levels than any other section below Peoria Lake, the amount of vegetation bordering on channel of normal width (excluding such areas as Havana Lake) has not in any recent season been very important. In a local flat stretch of a quarter mile on the west side above Liverpool, where there was more shore vegetation both in 1913 and 1914 than anywhere else between the dam and the head of Havana Lake, the extreme width of the weed strip was about 35 feet, a little less than 5% of the bank to bank width at the time (about 750 feet); while for most of the distance it was not more than 15 feet. Nowhere else between Copperas Creek dam and the head of Havana Lake was there in 1913 or 1914 shore vegetation for any important distance that occupied more than a ten-foot strip next the bank, and there were long stretches with much less than that amount. In the shore zones of the wide water above the mouth of Spoon River there are several acres of Potamogeton on the west side in the most favorable seasons; and on the east side a narrower strip, sometimes up to 50 or 60 feet wide, in a stretch of about 300 yards along the edge of Cook's Island. Even these local areas, relatively to the vastly greater river acreages wholly without aquatic vegetation in the 16.8 miles, are extremely small, and revert largely to open water in all but the driest seasons.

Bottom Fauna.—A total of 16 channel collections and 23 collections in the shore zones (within the 7-foot line) were made in July–October, 1915, between Copperas Creek dam and Havana in cross-section: at

Bottom Collections, Copperas Creek Dam to Havana
July–October, 1915

	Channel	4—7-ft. zone	1—3-ft. zone
1. Copperas Creek dam to Mile 129			
Mile 135.2, opposite head of Senate Island	4	2	
Mile 133.6, opposite foot of Senate Island	4	2	
2. Mile 129 to Havana			
Mile 128.5, ½ mile above Liverpool	5	5	4
Mile 123.0, 3 miles above Havana	3	8	2
Total	16	17	6

two stations in the shallower swifter section of 7.8 miles between the dam and Mile 129 (1 mile above Liverpool); and at two stations in the deeper more stagnant section of 9 miles between Mile 129 and Havana.

Although the entire section of over 16 miles is on the average richer in small bottom animals than any other sections heretofore treated, biologically, as well as in its hydrographical characters, it is separable into two well-distinguished portions, the half with the richer channel bottom fauna being the deeper muddier section below Mile 129 and more immediately above the high Spoon-River bar. The average of the poundages per acre at the channel stations in the lower half of the section (5,156.0 lbs.) was in fact nearly six times the average valuation of channel above Mile 129 (878.3 lbs. per acre), and almost fifteen times the average valuation at the channel stations between Chillicothe and the foot of Peoria Lake, Peoria Narrows excepted (345.1 lbs.).

Bottom Fauna, 1915, Copperas Creek Dam to Havana
pounds per acre (average total)

	Channel	4—7-ft. zone	1—3-ft. zone
1. Copperas Creek dam to Mile 129 (7.8 miles)	878.3	1,436.2	No collections
2. Mile 129 to Havana (9 miles)	5,180.8	2,122.0	919.7

In the channel collections both above and below Liverpool the larger Viviparidae made up more than 99% of the weight of the average collection. The Sphaeriidae and the smaller Gastropoda amounted in weight to a mere trace in comparison; while the insects, worms, and small Crustacea accounted for less than half of one per cent. of the average poundages.

Bottom Fauna, Channel, Copperas Creek Dam to 1 Mile above Liverpool, 1915

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	263.4	0.3	28.3	292.0 8 coll.'s
Pounds per acre, Average	874.2	0.1	4.0	878.3 8 coll.'s
Per cent. of total, (By weight)	99.5%	trace	0.4%	

Bottom Fauna, Channel, 1 Mile above Liverpool to Havana, 1915

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	1,294.0	3.0	171.8	1,468.8 8 coll.'s
Pounds per acre, Average	5,156.0	0.1	24.7	5,180.8 8 coll.'s
Per cent. of total, (By weight)	99.5%		0.4%	

Average bottom-fauna poundages in the 4–7-foot zone above Mile 129 in 1915 (1,436.2 lbs. per acre) were nearly twice those in the channel opposite (878.3 lbs.). Below Mile 129, where they were 2,122.0 lbs. they were less than half the average channel valuation (5,180.8 lbs.). No collections were taken above Mile 129 within the 4-foot line, but between Liverpool and Havana six collections in the 1–3-foot zone showed an average valuation of 917.7 lbs. per acre. In the 4–7-foot zone, both above and below Liverpool, Sphaeriidae were relatively much more abundant than either in the channel or the 1–3-foot zone, making 40 to 80% of the average weight of collections. In the 1–3-foot zone below Mile 129 the weight-composition of the bottom fauna was on the whole nearly identical with that of the channel (Viviparidae and Pleuroceridae 96%; Sphaeriidae and smaller Gastropoda 2.3%; insects, etc., 1.1%).

Bottom Fauna, 4—7-foot Zone, Copperas Creek Dam to 1 Mile above Liverpool, 1915

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	302.2	1,212.5	96.0	1,610.4 4 coll.'s
Pounds per acre, Average	814.3	606.2	15.7	1,436.2 4 coll.'s
Per cent. of total, (By weight)	56.6%	42.2%	1.0%	

Bottom Fauna, 4—7-ft. Zone, 1 Mile above Liverpool to Havana, 1915

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	120.8	3,537.3	172.0	3,830.1 13 coll.'s
Pounds per acre, Average	319.3	1,776.7	26.0	2,122.0 13 coll.'s
Per cent. of total, (By weight)	15.0%	83.7%	1.2%	

Bottom Fauna, 1—3-ft. Zone, 1 Mile above Liverpool to Havana, 1915

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	230.6	38.5	81.0	350.1 6 coll.'s
Pounds per acre, Average	887.6	21.6	10.5	919.7 6 coll.'s
Per cent. of total, (By weight)	96.5%	2.3%	1.1%	

(e) Havana to Lagrange Dam (42.5 Miles)

Hydrography.—While the 42.5 miles of channel between Havana and Lagrange has on the whole a swifter flow than the flatter reaches above Havana, it is separable into three subdivisions which show distinct differences in slope and current:

1. The 17.2 miles between Havana and Sheldon's Grove (approximately Sharp's Landing), which has a low-water slope about the same as Liverpool–Havana (0.53 inch per mile, low water, 1901), and a flood velocity more than twice as great (140.91 feet per minute, March, 1903).

2. The 13.3 miles between Sheldon's Grove and one mile above Beardstown, which had a low-water slope in 1901 (1.08 inches per mile) about double that of the first 17 miles, but a flood velocity (116.06 feet per minute, March, 1903) less than that of the first section.

3. The 12.0 miles between a point one mile above Beardstown and the dam at Lagrange, where the slope of water surface in July, 1901, was only 0.10 inch per mile. but the flood velocity (152.04 feet per second in March, 1903) greater even than between Havana and Sheldon's Grove.

DECLINE IN ELEVATION OF LOW-WATER SURFACE, 1901; AND FLOOD VELOCITY

Reach	Interval miles	Average slope inches per mile	Flood velocity (av. ft. per minute. gage, 18 ft., Peoria)
Havana to Sheldon's Grove	17.2	0.62	140.91 (17.2 miles)
Sheldon's Grove to 1 mile above Beardstown	13.3	1.08	116.06 (14.3 miles)*
1 mile above Beardstown to Lagrange dam	12.0	0.10	152.04 (11.0 miles)*

The principal part of the first subdivision (the 13.8 miles between Havana and the foot of Grand Island) as well as the lower 19.5 miles of the reach (Browning to the dam), together making more than three fourths of the entire reach of 42.5 miles, is comparatively wide and shallow, and has almost entirely sand or sand and shell bottom channel. The muds found at the shore stations in 1915 were both lighter in color and also less soft and deep than the soft shore deposits found above Havana. At the low levels of 1901, depths in the channel between Havana and the foot of Grand Island were as a rule 8 to 10 feet and ran at most a little over 12; while below Browning they ranged usually between 10 and 12 feet and for short distances reached 13 to 15. Depths at recent midsummer low levels have been 2 to 3 feet greater than these. Widths at the low water of 1901 of single channel between Havana and the foot of Grand Island were mostly 600 to 700 feet, and exceeded 750 feet for short stretches; and between Browning and the dam were usually over 700 feet and for good distances between 800 and 1,000.

The central section of about 9 miles of channel lying immediately above the mouth of the Sangamon River (approximate foot of Grand Island to 1 mile above Browning) is much narrower and deeper than the stretches of channel above and below it, and has a mud bottom. Depths in this section of channel at the 1901 low levels were nearly everywhere 15 to 20 feet; while bank to bank width was usually under 600 feet and fell for good distances under 500. The deep natural pool lying above the Sangamon River bar is a homologue of those above the great Farm Creek and Havana bars already described, and is of less moment biologically, in the respect of furnishing a very rich soil for bottom animals, only because the entrance of this large tributary occurs in the very midst of a long stretch of river with naturally steep gradient, where

* Nearest corresponding velocity-reaches (Van Ornum float tests, March, 1903). stop at Beardstown.

both increased velocities and increased flood volumes retard sedimentation and keep the summit of the bar lower than in the other two cases.

Lake and other backwater acreage per mile between Havana and the Lagrange dam (382.4 acres) exceeded at the low water of 1901 that of any other reach of river except the 16.8 miles between Copperas Creek dam and Havana.* The densest distribution of pond acreage occurs in the 9 miles between the foot of Grand Island and the mouth of the Sangamon and falls within the boundaries of greatest channel depths, least flood velocity, softest and darkest-colored bottom deposits, and richest bottom fauna, as shown by our collections of 1915.

WIDTHS AND DEPTHS, HAVANA TO LAGRANGE DAM, LOW WATER, 1901

Miles above Grafton	Station	Width, ft.	Depth, ft. max.	
119.0	1 mile below Havana	658	8.5	1. Havana to foot of Grand Island. Shallow section
118.1	.....	768	8.7	
117.5	.....	549	10.7	
116.0	.....	640	10.0	
115.0	.....	530	12.5	
114.0	.....	732	8.3	
113.5	Head of Grand Island	712	9.0	
111.9	.....	457	9.1	
110.0	.....	...	7.0	West channel only
108.0	.....	...	11.0	
106.5	1/3 mile above foot of Grand Island....	514	14.7	
106.2	Foot of Grand Island	658	12.4	2. Foot of Grand Island to Browning. Narrow, deep section
104.0	.....	475	18.4	
102.8	Sheldon's Grove.....	582	15.6	
101.6	.....	439	20.4	
98.0	Mouth of Sangamon..			
98.2	.....	...	17.0	
97.0	1/4 mile below Browning	494	13.4	3. Browning to Lagrange dam. Wide, shallow section
95.7	1½ miles below Browning	878	8.7	
93.0	.....	750	8.3	
90.3	.....	732	10.2	
89.1	.....	658	13.2	
88.2	1/4 mile below wagon bridge, Beardstown	...	12.8	
86.2	.....	1,006	10.2	
84.2	.....	1,000	13.1	
83.6	.....	514	12.1	
82.6	.....	841	8.5	
81.5	.....	732	10.5	
80.4	.....	732	11.7	
78.8	.....	...	15.0	
78.6	.....	805	11.8	
77.7	250 yards above Lagrange dam	933	11.7	

* Table, p. 378.

Bottom Fauna.—A total of 58 bottom collections, at 9 stations, in cross-section, were taken in 1915 between Havana and the Lagrange dam, distributed between the channel and the shore zones and from north to south as shown in the following table.

Collections, Havana to Lagrange Dam, 1915

Miles above Grafton	Station	Channel	4—7-ft. zone	1—3-ft. zone
	1. Havana to foot Grand Island (13.8 miles)			
114.7	Opposite foot Matanzas Lake	3	2	
113.7	500 yards above head of Grand Island	3	2	8
	2. Foot Grand Island to Browning (9.0 miles)			
101.0	Opposite foot of Stewart Lake	1	4	2
97.0	1/4 mile below Browning	1	6	2
	3. Browning to Lagrange dam (19.7 miles)			
89.5	1 mile above Beardstown	1	6	2
84.0	Brigg's Landing	2		
83.2	Reich's Landing	2		
80.3	Lagrange Landing	2		
77.7	200 yards above dam	1	2	6
	Total	16	22	20

With reference to the bottom fauna this reach of 42.5 miles may be described as a whole as a section of exceedingly poor channel, bordered on either side by a comparatively rich shore fauna. The average channel poundages of bottom animals taken in 1915 between Havana and the dam at Lagrange was only 22 lbs. per acre, or not much more than one fifteenth of average channel valuation between Chillicothe and the foot of Peoria Lake (345 lbs.), and less than one two-hundredths of the average between Liverpool and Havana (5,180 lbs.). While the channel fauna was about equally poor throughout the 42.5 miles in 1915, the shore fauna (bottom animals within the 7-foot line) was distinctly richest in the central deeper section of river above the mouth of Sangamon River, where the 4–7-foot zone showed figures (365.6 lbs. per acre) about 30% over the average of the 4–7-foot zone for the 42.5 miles, and the 1–3-foot zone a rating (1,613.4 lbs. per acre) nearly four times the 42-mile average, or more in fact than was found anywhere else at that depth between Chillicothe and Grafton. The greater part of the weight of the average collections in the 42 miles, whether from channel or shore zones, consisted of the larger snails (Viviparidae). Though larvae of caddis-flies and nymphs of May-flies were relatively commoner than above Havana, they were not numerous enough anywhere to contribute

importantly to weights, making up at the best only about 6 pounds of the total acre valuation.

BOTTOM FAUNA, 1915, HAVANA TO LAGRANGE DAM
POUNDS PER ACRE, AVERAGE TOTALS

Reach	Channel	4—7-ft. zone	1—3-ft. zone
1. Havana to Lagrange dam (42.5 miles)	22.0	282.6	435.5
2. Foot of Grand Island to Browning (9 miles)	12.5	365.6	1,613.4

BOTTOM FAUNA, 1915, CHANNEL, HAVANA TO LAGRANGE DAM (42.5 MILES)

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	5.5	6.0	3.7	15.2 16 coll.'s
Pounds per acre, Average	16.0	3.0	3.0	22.0 16 coll.'s
Per cent. of total, (By weight)	72.7%	13.6%	13.6%	

BOTTOM FAUNA, 1915, 4—7-FOOT ZONE, HAVANA TO LAGRANGE DAM (42.5 MILES)

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	73.0	88.0	31.1	192.1 22 coll.'s
Pounds per acre, Average	234.8	42.1	5.7	282.6 22 coll.'s
Per cent. of total, (By weight)	83.0%	14.8%	2.0%	

BOTTOM FAUNA, 1915, 1—3-FOOT ZONE, HAVANA TO LAGRANGE DAM (42.5 MILES)

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	99.3	91.1	18.3	208.6 20 coll.'s
Pounds per acre, Average	385.7	44.6	5.2	435.5 20 coll.'s
Per cent. of total, (By weight)	88.5%	10.2%	1.1%	

BOTTOM FAUNA, 1915, CHANNEL, FOOT OF GRAND ISLAND TO BROWNING (9 MILES)

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	2.7	2.5	1.0	6.2 2 coll.'s
Pounds per acre, Average	1.5	5.0	6.0	12.5 2 coll.'s
Per cent. of total, (By weight)	12.0%	40.0%	48.0%	

BOTTOM FAUNA, 1915, 4—7-FOOT ZONE, FOOT OF GRAND ISLAND TO BROWNING (9 MILES)

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	92.4	106.4	10.3	209.1 10 coll.'s
Pounds per acre, Average	309.7	53.2	4.5	365.6 10 coll.'s
Per cent. of total, (By weight)	84.2%	14.5%	1.2%	

BOTTOM FAUNA, 1915, 1—3-FOOT ZONE, FOOT OF GRAND ISLAND TO BROWNING (9 MILES)

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Number per sq. yard, Average	327.4	186.2	26.1	539.7 4 coll.'s
Pounds per acre, Average	1,516.0	93.1	4.3	1,613.4 4 coll.'s
Per cent. of total, (By weight)	93.9%	5.7%	0.2%	

(f) LAGRANGE DAM TO GRAFTON (77.5 MILES)

Hydrography.—The average velocity in the 77.5 mile stretch of channel between the Lagrange dam and the mouth of the river in March, 1903, at a gage of about 18 feet, Peoria, (172.30 feet per minute), was more than three times that between Chillicothe and Peoria at the same time (51.94 ft. per minute); more than twice that between Copperas Creek dam and Havana (83.81 ft.); and exceeded that of any other section of channel below Chillicothe except the 9 miles between Peoria and Pekin. The average decline in elevation of water surface at the 1901 low gages between Lagrange and the dam at Kampsville (0.85 inches per mile) was more than three times the average through Peoria Lake; and

DECLINE IN ELEVATION OF LOW-WATER SURFACE, 1901; AND FLOOD VELOCITY

Reach	Interval miles	Av. slope inches per mile	Flood velocity (av. feet per minute), gage, 18 feet, Peoria*
Lagrange dam (below) to Grafton	77.5	...	172.30
Lagrange dam (below) to Kampsville dam (above)	46.1	0.85	164.24
Lagrange dam (below) to Florence	21.9	1.26	146.92
Florence to Kampsville dam (above)	24.2	0.49	183.85
Kampsville dam (below) to Grafton	31.4	2.44	186.91

* Van Ornum float tests, March, 1903.

in the 31 miles below Kampsville (2.44 inches per mile) was more than in the short swift stretch between Peoria and Pekin.

A comparatively well-scoured channel bottom is found most of the way from Lagrange to the mouth, sand, mud and shell, or dirty sand prevailing, and such mud bottom as occurs being usually hard and covered at most with only a very thin layer of recent silt. Inside the 7-foot line in 1915 a soft light-colored silt 2 inches to more than 12 inches deep was found at most of our collecting stations. The most important local stretches of muddy channel in 1915 were 6 miles immediately above the Kampsville dam; and about 4 miles just above the mouth of the river. A less important short section of muddy channel, in

WIDTHS AND DEPTHS, LAGRANGE DAM TO GRAFTON, LOW WATER, 1901

Miles above Grafton	Station	Width, ft.	Depth, ft. max.
77.0	½ mile below Lagrange dam	658	13.1
72.7	.....	805	8.2
72.3	.....	586	14.0
71.6	.....	658	12.7
71.5	Meredosia	1,006	9.1
68.0	.....	658	15.7
66.5	.....	1,006	10.3
65.5	Naples	787	8.7
64.0	.....	951	6.9
62.5	.....	823	9.3
61.4	.....	567	15.3
59.0	.....	1,024	6.9
55.5	Florence	1,025	8.8
54.5	.....	658	15.6
53.5	.....	975	9.0
47.5	.....	1,116	10.9
44.0	.....	933	10.3
41.2	2 miles below Pearl.....	1,317	10.5
39.2	.....	1,409	12.3
36.7	.....	1,482	10.2
34.5	.....	1,043	14.5
33.0	1 mile above Kampsville....	1,354	11.3
31.8	500 yards above dam.....	1,180	13.7
31.3	300 yards below dam.....	1,317	10.0
29.8	.....	1,006	20.0
25.8	.....	1,079	9.2
21.3	Hardin	1,134	8.1
20.3	.....	1,116	6.5
16.9	.....	1,208	7.2
12.3	.....	768	14.7
11.5	.....	1,061	8.1
10.0	.....	732	19.2
8.5	.....	1,189	7.8
7.3	Foot of Six Mile Island.....	1,610	8.7
6.5	.....	1,098	14.0
5.5	.....	1,263	14.2
4.0	.....	768	14.4
3.0	1 mile above mouth.....	677	18.4

the first mile below Six Mile Island—a local section with little drop in levels at low water—had a deep deposit of light-colored mud in 1913, but apparently much less two years later.

In the 46 miles between Lagrange and Kampsville extreme depths in the channel at the low water of 1901 ranged from 9 to 11 feet as a rule, and did not anywhere exceed 15 feet. Widths at these levels were between 1,000 and 1,400 feet for good stretches, and did not fall below 800 feet for any important distance. Below the Kampsville dam widths were seldom under 800 feet, ranging between 1,000 and 1,200 feet for most of the way, and reaching a maximum of 1,600 in the sluggish section just below Six Mile Island.

Connecting lake and other backwater acreage per mile between Lagrange and the mouth of the Illinois at the low levels of 1901 (219.6 acres per mile between Lagrange and Florence; 180.0 between Florence and Kampsville; 86.9 between Kampsville and the mouth) compared unfavorably with that of most of the river between Chillicothe and Havana.* The greater part of this backwater was leveed and drained between 1901 and 1913, resulting, no doubt, in recent years in a somewhat better scoured channel even than is indicated by the government borings made between 1901 and 1905. As in the 42 miles above the Lagrange dam, shore vegetation between Lagrange and the mouth of the river has in recent years been a negligible quantity.

Bottom Collections, Lagrange to Grafton, 1915

Miles above Grafton	Station	Channel	4—7-ft. zone	1—3-ft. zone
71.7	½ mile above Meredosia	1	2	8
60.0	1½ miles below Valley	1		
55.6	Opposite Florence	1		
54.5	1 mile below Florence	1		
	Total	4	2	8
47.7	¾ mile below Bedford	1	6	4
43.2	Opposite foot Pearl Island	1	5	2
36.5	½-way Apple Creek to Panther Cr.	1	6	2
33.0	1 mile above Kampsville	1		
31.6	300 yards above Kampsville dam	1		
	Total	5	17	8
25.7	Opposite (west) head Diamond Island	1		
20.6	½ mile below Hardin	1	2	4
11.5	1 mile below foot Mortland Island	1	4	2
9.3	Opposite Bloom's Landing	2		2
8.5	Opposite head Six-Mile Island	1	4	
7.3	Below foot Six-Mile Island	1	2	4
	Total	7	12	12
	Grand total	16	31	28

* Table, p. 378.

Bottom Fauna.—In August, 1915, a total of 75 collections of the bottom animals were made in cross-section at 15 stations between Lagrange dam and the mouth of the river, as shown in the preceding table.

The bottom-fauna valuations indicated between Lagrange and Grafton by our collections of August, 1915, were almost uniformly poor both in the shore zones and in the channel—the average of the sixteen channel collections being only 6.7 lbs. per acre; that of 31 collections between 4–7-feet, 16.7 lbs.; and that of 28 collections within the 4-foot line, 16.9 lbs. The best local figures for the shore were obtained in the 4–7-foot zone opposite Meredosia, where two hauls averaged 57.5 lbs. per acre; and in the 1–3-foot zone below Kampsville dam, where twelve collections averaged 27.9 lbs. Both in the channel and in the shore zones, if we except the 4–7-foot zone collections opposite Meredosia, Mollusca contributed less or very little more to the average weight of collections than did insects, worms, and small Crustacea, which together made up 63 to 65% of the average weight of collections in those depths zones, with the noted exception. Of the latter group (non-Mollusca) the most important in weight were the larvae of caddis-flies in the channel, and the immature stages of Ephemeridae (willow-flies) in the shore zones. As these were principally of the new broods hatched from eggs deposited by the adults which emerged only a month to six weeks earlier, they contributed less to the weight of collections than they would have done in the same numbers earlier in the summer or later in the fall. The larger snails (Viviparidae and Pleuroceridae) amounted nowhere below Lagrange to more than 5 or 10% of the weight of collections.

BOTTOM FAUNA, 1915, LAGRANGE TO GRAFTON
POUNDS PER ACRE (AVERAGE TOTAL)

Reach	Channel	4—7-ft. zone	1—3-ft. zone
1. Lagrange dam to Florence (21.9 miles)	*4**	57.5 *2*	10.1 *8*
2. Florence to Kampsville, above dam (24.2 miles)	12.4 *5*	16.6 *17*	7.5 *8*
3. Kampsville above dam to Grafton (31.4 miles)	6.5 *7*	10.3 *2*	27.9 *12*
Lagrange to Grafton (77.5 miles)	6.7 *16*	16.7 *21*	16.9 *28*

* The Italic figures give the number of collections.

BOTTOM FAUNA, CHANNEL, LAGRANGE TO GRAFTON, 1915
POUNDS PER ACRE

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Lagrange dam to Florence 4 coll.'s	....	....	....	trace
Florence to Kampsville 5 coll.'s	5.0	1.5	5.9	12.4
Kampsville to Grafton 7 coll.'s	....	2.6	3.9	6.5
Lagrange to Grafton 16 coll.'s	0.3	1.6	3.5	5.4
Per cent. of total (by weight)	5.5%	29.6%	64.8%	

BOTTOM FAUNA, 4—7-FOOT ZONE, LAGRANGE TO GRAFTON, 1915
POUNDS PER ACRE

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Lagrange dam to Florence 2 coll.'s	....	57.5	....	57.5
Florence to Kampsville 17 coll.'s	0.6	10.3	5.7	16.6
Kampsville to Grafton 12 coll.'s	....	4.8	5.5	10.3
Lagrange to Grafton 31 coll.'s	Trace	11.2	5.2	16.4
Per cent. of total (by weight)	....	68.2%	31.8%	

BOTTOM FAUNA, 1—3-FOOT ZONE, LAGRANGE TO GRAFTON, 1915
POUNDS PER ACRE

	Viviparidae and Pleuroceridae	Small Gastropoda and Sphaeriidae	Insects, worms, Crustacea	Total
Lagrange dam to Florence 8 coll.'s	....	9.2	0.9	10.1
Florence to Kampsville 8 coll.'s	2.4	0.1	5.0	7.5
Kampsville to Grafton 12 coll.'s	0.3	6.3	21.3	27.9
Lagrange to Grafton 28 coll.'s	0.8	5.3	10.8	16.9
Per cent. of total (by weight)	4.7%	31.3%	63.9%	

(g) GENERAL SUMMARY, ILLINOIS RIVER BOTTOM FAUNA, JULY–OCTOBER, 1915

1. DISTINCTION OF MAIN REACHES

If we have regard only to the larger average differences in weight of the bottom-fauna stocks of 1915, the 180.5 mile stretch of river between Chillicothe and Grafton separates into four principal subdivisions:—First, a section of 43.7 miles between Chillicothe and the dam at Copperas Creek which bears a fairly rich channel- and a similarly rich shore-fauna (channel average, 239 lbs. per acres; 4—7-foot zone, 372 lbs.; 1—3-foot zone, 225 lbs.). Second, a short stretch between Copperas Creek dam and Havana which has an exceedingly rich channel fauna (3,029 lbs. per acre) and a shore fauna far above the average (4—7-foot zone, 1,960 lbs.; 1—3-foot zone, 920 lbs.). Third, 42.5 miles between Havana and the dam at Lagrange with very poor channel (22 lbs. per acre) but with shore as rich as in the first 60 miles (4—7-foot zone, 282 lbs.; 1—3-foot-zone, 435 lbs.). Fourth, in the lower 77.5 miles, a long reach that is extremely poor both in shore and channel (channel, 6 lbs. per acre; both shore zones, 17 lbs.).

Whether in the shore or the channel zones, so far as is shown by the data of 1915, the richest stocks of small bottom-invertebrates are present in the reaches with the least flood slope and velocity, these

factors clearly influencing—more particularly, of course, in the channel—both the depth and softness of the bottom deposits (regarded as a medium or as a substratum for the bottom population), and also the food supply of the bottom animals so far as it is brought to them by sedimentation. In the two richer reaches of river above Havana the average flood velocity in recent years (around 0.9 miles per hour) has been only about ⅗ of that between Havana and Lagrange (1.5 miles per hour), and less than half the average between Lagrange and Grafton (1.9 miles per hour).

Though there is usually, both in the slower and swifter reaches of the river, if we except the cases of some sharp bends, some retardation of current between mid-channel and shore, with accompanying increase in sedimentation and noticeable differences in the composition of the bottom populations, these differences in the less rapid sections above Havana are neither very important quantitatively nor correlated so far as can be seen. The average poundages per acre of bottom animals between Chillicothe and Copperas Creek dam in the channel and the shore zones (channel, 239 lbs.; 4—7-foot zone, 372 lbs.; 1—3-foot zone, 225 lbs.) are in fact so nearly the same that little if any significance can be attached to the differences; while in the 16.8 miles between Copperas Creek and Havana (channel, 3,029 lbs.; 4—7-foot zone, 1,960 lbs.; 1—3-foot zone, 920 lbs.) the differences in weight between the shore and channel stocks are in the reverse of the direction that might be expected. There is, however, a decidedly sharper contrast below Havana between the physical characters of the channel and shore zones, and in and to either side of the stretch of comparatively hard-bottomed channel between Havana and Lagrange a corresponding contrast in the richness of the bottom fauna that is without much question connected with it. In this section of 42.5 miles the 4—7-foot zone (282 lbs. per acre) had stocks thirteen times as rich as those of the channel (22 lbs.); and there was a further large increase shown in the stocks in the 1—3-foot zone.

Certain special influences that may affect the bottom-fauna yields in the river below the Lagrange dam are discussed in a following section.

2. ALL-ZONE AVERAGES AND TOTAL STOCKS

All-zone averages of the bottom-fauna stocks of the four main river reaches below Chillicothe based upon rough acreage-weightings show a figure for the first 43.7 miles below Chillicothe (264 lbs. per acre) about the same as the average for the entire 180.5 miles between Chillicothe and Grafton (261 lbs.); for the 16.8 miles between Copperas Creek dam and Havana about ten times that (2,693 lbs.); for the 42.5 miles between Havana and Lagrange a rate of yield (88 lbs. per acre) about one third of the general river average and about one thirtieth of the rate in the richest section; and for the 77.5 miles below Lagrange (10.4 lbs. per acre) less than one twenty-fifth of the 180 mile average and less

BOTTOM FAUNA, ILLINOIS RIVER, 1915. SIMPLE SINGLE-ZONE AVERAGES

POUNDS PER ACRE

Reach	Miles	Channel zone	4—7-ft. zone	1—3-ft. zone	Average velocity flood gage 18 ft. Peoria ft. per min.	Average velocity miles per hour
Chillicothe to Copperas Creek dam	43.7	239 *30**	372 *83*	225 *17*	80.87	0.9
Copperas Cr. dam to Havana	16.8	3,029 *16*	1,960 *17*	920 *6*	83.81	0.9
Havana to Lagrange	42.5	22 *16*	282 *22*	435 *20*	134.37	1.5
Lagrange to Grafton	77.5	6 *16*	17 *31*	17 *28*	172.30	1.9
Total	180.5 miles					

* The Italic figures give the number of collections.

than one two-hundredth of the rate between Copperas Creek dam and Havana.

Figures for the total stocks present in the combined channel and shore acreage below Chillicothe July–October 1915 (table, p. 18), based on these all-zone weight valuations and on approximate acreages for average July–October levels in 1910—1914, show that out of total stocks equaling 6,988,103 pounds for about 26,700 acres, 92.7 per cent., or 6,480,952 pounds, were in the 60.5 mile section of river above Havana—this constituting only one third of the total length of river studied and less than one third of the total river acreage. Again, of the total bottom-fauna stocks 53.9%, or 3,770,200 pounds, were in the 16.8 miles of river between Copperas Creek and Havana—which comprises less than one tenth of the total distance between Chillicothe and the mouth, and only about one twentieth of the total acreage. The stocks between Havana and Lagrange, 396,880 lbs., for 42.5 miles, made up but 5.6% of the grand total; and those between Lagrange and Grafton, 110,271 lbs., for 77.5 miles, only 1.5 per cent.

Bottom Fauna, Illinois River, 1915. Acreage-weighted All-Zone Averages

POUNDS PER ACRE

Reach	Miles	Approx. acres Gage, 8 ft. Havana	Estimated part of total under 7 ft. deep	Bottom fauna lbs. per acre (average)
Chillicothe to Copperas Creek dam	43.7	10,268*	1/3	264 *80*†
Copperas Creek dam to Havana	16.8	1,400	1/4	2,693 *39*
Havana to Lagrange	42.5	4,510	1/5	88 *58*
Lagrange to Grafton	77.5	10,603	2/5	10.4 *75*
Chillicothe to Grafton	180.5	26,782	...	261 *252*

Average Chillicothe to Copperas Creek dam, 555 lbs.
Average Copperas Creek dam to Lagrange, 705 lbs.

3. COMPOSITION OF THE BOTTOM FAUNA

In the section of river above Lagrange dam, both in the channel and in the shore zones, the great bulk of the bottom-fauna poundages was made up of Mollusca (Gastropoda and Sphaeriidae), the percentages by

* Includes Peoria Lake.
† The Italic figures give the number of collections.

BOTTOM-FAUNA STOCKS, ILLINOIS RIVER MAIN REACHES, AND GRAND TOTAL, CHILLICOTHE TO GRAFTON, JULY—OCTOBER, 1915

Reach	Miles	Approx. acres Gage, 8 ft. Havana	Bottom fauna lbs. per acre	Total bottom-fauna stocks pounds	Per cent. of total stocks
Chillicothe to Copperas Creek dam	43.7	10,268*	264	2,710,752	38.7%
Copperas Creek dam to Havana	16.8	1,400	2,693	3,770,200	53.9%
Havana to Lagrange dam	42.5	4,510	88	396,880	5.6%
Lagrange dam to Grafton	77.5	10,603	10.4	110,271	1.5%
Chillicothe to Grafton	180.5	26,782	261	6,988,103	
Copperas Creek dam to Grafton	136.8	16,514	259	4,277,351	
Copperas Cr. dam to Lagrange dam	59.3	5,911	705	4,167,080	59.6%
Chillicothe to Havana	60.5	11,668	555	6,480,952	92.7%

* Including Peoria Lake.

weight running in these reaches from 86 to over 99%, and falling below 90% only in the 1—3-foot zone above the Copperas Creek dam. Below the Lagrange dam, where the large Ephemeridae (May-flies) were relatively much more abundant than farther north, the Mollusca percentages dropper to an average range between 35 and 68%.

In the sections above Lagrange, if we except the 4—7-foot zone between Copperas Creek dam and Havana, the larger snails (Viviparidae and Pleuroceridae) accounted for 70 to nearly 100% of the Mollusca totals (by weight). Below Lagrange the Viviparidae (and Pleuroceridae) were largely replaced by Sphaeriidae in all zones, the weight percentages of that group rising to a range between 84 and 100%.

Bottom Fauna, Illinois River, 1915
Percentages of Average Total Valuations by Weight contributed by Mollusca

	Channel	4—7-ft. zone	1—3-ft. zone
Chillicothe to Copperas Creek dam	96.7	97.3	92.1
Copperas Creek dam to Havana	99.5	98.8	98.8
Havana to Lagrange	86.3	98.1	98.9
Lagrange to Grafton	31.6	65.8	35.8

Bottom Fauna, Illinois River, 1915
Composition of Mollusca Totals. (Percentages by Weight*)

Reach	Viviparidae and Pleuroceridae			Sphaeriidae and small Gastropoda		
	Channel	4—7-ft. zone	1—3-ft. zone	Channel	4—7-ft. zone	1—3-ft. zone
Chillicothe to Copperas Creek dam	78.5	78.1	70.7	21.5	21.9	29.3
Copperas Creek dam to Havana	100.0	22.5	97.7	trace	77.5	2.3
Havana to Lagrange	84.3	84.8	89.7	15.7	15.2	10.3
Lagrange to Grafton	15.8	none	13.2	84.2	100.0	86.8

* Pound values on which these percentages are based are shown in following tables.

ILLINOIS RIVER, 1915, CHANNEL
BOTTOM FAUNA, POUNDS PER ACRE. (SUMMARY)

Reach	No. of collections	Viviparidae etc.	Sphaeriidae etc.	Insects etc.	Total	Per cent. Mollusca
Chillicothe to Mossville	8	244.1	70.4	3.1	317.6	99
Narrows to foot of Peoria L.	4	391.6	3.1	5.6	400.3	98
Foot of Peoria L. to Pekin	4	224 6	8,3	20.9	253.8	91
Pekin to Copperas Cr. dam	14	73.3	63.4	8.1	144.8	94
Average*	30	181.4	49.8	8.1	239.3	96.6
Copperas Cr. dam to Liverpool	8	874.2	0.1	4.0	878.3	99
Liverpool to Havana	8	5156.0	0.1	24.7	5180.8	99
Average*	16	3015.1	0.1	14.3	3029.4	99.5
Havana to Lagrange	16	16.0	3.0	3.0	22.0	86.3
Lagrange to Florence	4				trace	
Florence to Kampsville	5	5.0	1.5	5.9	12.4	52
Kampsville to Grafton	7		2.6	3.9	6.5	40
Average*	16	0.3	1.6		5.4	35.1

* Subreach averages each multiplied by number of collections; then sum of products divided by total number of collections.

ILLINOIS RIVER, 1915, 4—7-FOOT ZONE
BOTTOM FAUNA, POUNDS PER ACRE. (SUMMARY)

Reach	No. of collections	Viviparidae etc.	Sphaeriidae etc.	Insects etc.	Total	Per cent. Mollusca
Chillicothe to Mossville	16	97.4	86.7	13.3	197.4	93
Narrows to foot of Peoria L.	4	446.3	55.5	5.8	507.6	98
Foot of Peoria L. to Pekin	4	60.0	136.7	9.6	206.3	95
Pekin to Copperas Cr. dam	9	638.0	52.4	5.1	695.5	99
Average	33	282.5	79.6	9.7	371.8	97.4
Copperas Cr. dam to Liverpool	4	814.3	606.2	15.7	1436.2	98
Liverpool to Havana	13	319.3	1776.7	26.0	2122.0	98
Average	17	435.7	1501.2	23.5	1960.4	98.8
Havana to Lagrange	22	234.8	42.1	5.7	282.6	98.1
Lagrange to Florence	2		57.5		57.5	100
Florence to Kampsville	17	0.6	10.3	5.7	16.6	65
Kampsville to Grafton	12		4.8	5.5	10.3	46
Average	31	trace	11.2	5.2	16.4	68.2

ILLINOIS RIVER, 1915, 1—3-FOOT ZONE
BOTTOM FAUNA, POUNDS PER ACRE. (SUMMARY)

Reach	No. of collections	Viviparidae etc.	Sphaeriidae etc.	Insects etc.	Total	Per cent. Mollusca
Chillicothe to Mossville	9	30.1	61.2	7.9	99.2	92
Narrows to foot of Peoria L.	1					
Foot of Peoria L. to Pekin	None	174.0	9.8	7.4	191.2	96
Pekin to Copperas Cr. dam	7	292.4	67.8	31.2	391.4	92
Average	17	146.5	60.8	17.4	224.7	92.2
Copperas Cr. dam to Liverpool	None					
Liverpool to Havana	6	887.6	21.6	10.5	919.7	98
Average	6	887.6	21.6	10.5	919.7	98.8
Havana to Lagrange	20	385.7	44.6	5.2	435.5	98.9
Lagrange to Florence	8		9.2	0.9	10.1	91
Florence to Kampsville	8	2.4	0.1	5.0	7.5	33
Kampsville to Grafton	12	0.3	6.3	21.3	27.9	24
Average	28	0.8	5.3	10.8	16.9	36.0

The Bottom Fauna of the Lakes and Ponds of the Illinois River Bottom-lands between Copperas Creek Dam and Lagrange, July—October, 1914—1915

1. Hydrography and Physical Features

In the midsummer and autumn months of 1914 and 1915 a total of 266 bottom collections, principally with the mud-dipper, were made in the lakes and ponds and other backwaters in the river bottoms between the head of Clear Lake and the foot of Sangamon Bay, covering a river distance of 39 miles, and representing an ex-river acreage (about 16,000 acres) at a gage of 8 feet, Havana, around one third of the total prevailing at the time between the Copperas Creek and Lagrange dams (about 52,000 acres).

The lakes and backwaters studied, separate naturally on a basis of physical and hydrographical features into five classes:

I. The deeper lakes of the all-bottom-land type, with flat muddy banks on both sides, and with maximum depths at recent midsummer levels between 7½ and 9 feet. The five lakes of this class examined—Clear—Mud, Liverpool, Thompson, Dogfish, and Sangamon Bay—have deep soft black mud bottom in the central deeper portions, and only rarely a little sand near shore. The vegetation, principally Potamogeton and Ceratophyllum, is confined to the rather wide shallow margins, the most of it well within the zone of 0—6 feet. These lakes ranged in size at the low water of 1901 (4.2 ft., Havana) from 275 to about 1,800 acres, and represented in all at that gage about 3,390 acres. At the average gage of July—October, 1910—1914 (approximately 8 ft., Havana), their acreage is somewhere near 2½ times the 1901 figures, or over 8,000 acres, which is close to one seventh of the total lake acreage between Copperas Creek dam and Lagrange, and more than the total river acreage at the same gage in the same distance (about 6,000 acres).

II. The deeper, sand-beach type, bordering on one side against the sandy bluff, and with sandy shore on that side, but with flat muddy banks opposite. The two lakes of this type studied (Quiver and Matanzas) had a total acreage at the low water of 1901 of more than 600 acres), and maximum depths at recent midsummer levels of 8½ to 12 feet. In Quiver Lake there is some sand and large quantities of old shells mixed with the mud in the deep "channel" which is kept open by the water from Quiver Creek during freshets. In Matanzas Lake the central open portion has all a soft black mud bottom. The vegetation in these two lakes is in its character and in its distribution not essentially different from that of the lakes of Class I, though it is inclined to be rather less dense on the average. These lakes receive a comparatively large amount of spring water from the sandy bluff on the east side, and their waters average somewhat clearer and (except at times of invasion by river water) poorer in plankton than the lakes of the all-bottom-land type.

III. The comparatively shallow, weedy lakes, with maximum depths at gage 8 feet, Havana, of about 5 feet. The lakes of this class in which collections were made in 1914 and 1915 (Flag, Seebs, Stewart) represented a total acreage at the low water of 1901 of about 1,500 acres, and at 8 feet, Havana, somewhere near 4,000. All of these lakes went completely dry in seasons of extreme low water before 1900. Both in the shallower and the deeper portions the black bottom deposits contain a much larger percentage of partially decayed dead vegetation than is found in the open waters of the lakes of Class I. In recent midsummer seasons, up to 1914, Flag and Seebs lakes have been almost completely filled with growing vegetation. In Stewart Lake at the same time some open water was to be found in the central deeper portion toward the foot, but much less relatively to the total area than was the case in such lakes as Thompson and other deeper lakes of its type.

IV. The very shallow, very weedy lakes, with greatest depths at the low water of 1910—1914 between 3½ and 4 feet. These lakes (Duck, Dennis, Crane) were little more than lily or flag ponds before 1900, going wholly dry at low water in most seasons before the opening of the Chicago Sanitary Canal. Between August and October, 1914, Duck and Dennis lakes were so filled with mixed vegetation that it was difficult to pass through them with a skiff, even the fallen dead stems of the coarse water-plants being blanketed with living filamentous algae. Crane Lake in 1914 and other recent years has been a vast lily-bed, with its rather more open, but densely shaded bottom sprinkled with dead lily stems and "yorkey-nuts". These three lakes had a low-water acreage in 1901 around 1,200 acres.

V. The shallow dead timber and brush areas first permanently submerged after the opening of the Sanitary Canal in January, 1900. These shallow backwaters, ranging in depth from 1½ to 4 feet over most of their areas, have alternating opener and densely weeded stretches, the prevailing vegetation being Potamogetom and Polygonum. Their location on the ridges between such lakes as Flag and Thompson, and on similar ridges between these lakes and others and the river, makes them in reality littoral, either of the river or of lakes of the preceding classes, as the case may be. Their bottom soil still contains abundant traces of the sticks and dead leaves contributed by the willows and mallows and button-bushes that grew there 20 years ago. The area represented by waters of this type can only, for the present, be roughly estimated. The total area under 4 feet in depth at the July–October levels of recent years between Copperas Creek and Lagrange dams (about 29,700 acres) made up over 50% of the total ex-river acreage, while careful estimates in the case of Thompson Lake as flooded to the same elevation (approx. Havana 8 ft.) indicated that on that gage in this lake these areas made up about 30% of the total land flooded. The dead timber and brush areas studied by us in 1914 and 1915 were all in the vicinity of Havana and were variously contiguous with Clear, Flag, Thompson, Dogfish, and Quiver lakes.

2. Bottom Fauna of the Lakes, by Classes

Class I.—Fifty-three collections from open water over 6 feet in depth in the deeper all-bottom-land lakes of Class I in 1914 and 1915 averaged 222 pounds per acre of bottom animals, after deducting shells of Mollusca. An average about twice as great (441 lbs.) was shown by 78 collections from the 1—6-foot zone, 21 of these hauls coming from open bottom and having an average of 696 lbs. per acre, and 57 from more or less weedy bottom, with an average of 347 lbs. The average of the total of 131 collections from the five lakes, all depths, in both seasons, was 352 pounds. Forty-two of the total 131 collections were taken in 1914 and 89 in 1915.

Thompson Lake, both in 1914 and 1915, easily outranked the other lakes of its class studied in the richness of its bottom fauna, its average of over 540 lbs. per acre, in either season, being more than double the best other lake average in this class, (Dogfish,) and nearly three times the lowest (Liverpool).

Class II.—The two sand-beach lakes (Quiver and Matanzas) showed a combined average for 1914 and 1915, for open water over 6 feet, of 1,667 lbs. per acre, for a total of 27 collections. Of these, 18 were from Quiver Lake, with an average of 2,471 lbs., and 9 from Matanzas Lake, with an average of only 58 lbs. per acre. The combined average of 37 collections, from the 1—6-foot vegetation zone, was 251 lbs., the average of Matanzas again being lower than that of Quiver. The general average, for the total of 64 collections, both lakes, both years, and all depths, was 848 lbs. per acre, or more than twice that of the lakes of Class I. It will be noted, however, that the very high average for this class and for Quiver alone, was largely due to a few enormous hauls of large Viviparidae in the deep "channel" in 1914. These were much reduced in numbers and weight per acre in 1915.

Classes III, IV, V.—The shallow weedy lakes of Class III, Flag, Seebs, and Stewart, averaged only 57 lbs. per acre, combined average of 45 collections, all depths, both seasons; and the very shallow, very weedy lakes (Duck—Dennis, Crane) only 94 lbs. per acre for a total of 10 collections. As will be shown in the next section, however, it was in these shallower, weedier lakes, and in other weedy backwaters, that the shore animals in the weeds (above the bottom) reach their highest figures. In the dead timber and brush areas the bottom-fauna average of 16 collections, 1914—1915 (187 lbs.) was better than in weedy lakes of Classes III and IV, approaching, in fact, the average of the open water of the deep lakes of the all-bottom-land type (222 lbs.).

Class I. Deep, bottom-land type			Pounds per acre			Pounds per acre subdivision, 1—6 ft.		Date collections
Lake	Acreage low water 1901	Max. depth Hav., 8 ft.	Open water over 6 ft.	1—6 ft. zone	All stations	No vegetation	Vegetation	
Clear—Mud	830 a.	8½ ft.	215.6 *8**	250.1 *12*	236.3 *20*	....	250.1 *12*	1915
Liverpool	320 a.	9 ft.	142.2 *6*	149.4 *9*	145.1 *15*	....	149.4 *9*	1915
Thompson	1,800 a.	9 ft.	310.7 *8*	612.9 *26*	541.7 *34*	903.2 *10*	431.5 *16*	1914
Thompson	(1,800 a.)	9 ft.	496.6 *8*	562.0 *19*	542.6 *27*	647.6 *7*	512.4 *12*	1915
Dogfish	165 a.	9 ft.	23.4 *3*	397.5 *5*	257.2 *8*	....	397.5 *5*	1914
Dogfish	(165 a.)	8½ ft.	152.0 *12*	134.3 *3*	148.4 *15*	....	134.2 *3*	1915
Sangamon	275 a.	7½ ft.	106.6 *8*	265.0 *4*	159.4 *12*	265.0 *4*	....	1915
Average	.....	.....	222 *53*	441 *78*	352 *131*	696 *21*	347 *57*	

* The Italic figures give the number of collections.

ILLINOIS VALLEY LAKES, BOTTOM FAUNA, 1914—1915

Class II. Deep, sand-beach type			Pounds per acre			Pounds per acre subdivision, 1—6 ft.		Date collections
Lake	Acreage low water 1901	Max. depth Hav., 8 ft.	Open water over 6 ft.	1—6 ft. zone	All stations	No vegetation	Vegetation	
Quiver	230 a.	12 ft.	2,805.0 *15**	388.3 *17*	1,521.1 *32*	....	388.3 *17*	1914
Quiver	(230 a.)	10 ft.	803.1 *3*	158.7 *14*	272.4 *17*	....	158.7 *14*	1915
Matanzas	390 a.	8½ ft.	58.6 *9*	77.9 *6*	66.3 *15*	....	77.9 *6*	1915
Average	.....	.....	1,667 *27*	251 *37*	848 *64*	.....	251 *37*	

* The Italic figures give the number of collections.

Class III. Shallow, weedy type			Pounds per acre			Pounds per acre subdivision, 1—6 ft.		Date collections
Lake	Acreage low water 1901	Max. depth Hav., 8 ft.	Open water over 6 ft.	1—6 ft. zone	All stations	No vegetation	Vegetation	
Flag	600 a.	5 ft.	....	70.9 *3**		....	70.9 *3*	1914
Flag	(600 a.)	5 ft.	....	27.9 *15*		....	27.9 *15*	1915
Seebs	Very small	5 ft.	....	124.0 *7*		....	124.0 *7*	1914
Seebs	.....	5 ft.	....	25.9 *8*		....	25.9 *8*	1915
Stewart	930 a.	5 ft.	....	73.8 *12*			73.8 *12*	1915
Average	.....	....	....	57 *45*	57 *45*	....	57 *45*	

* The Italic figures give the number of collections.

Class IV. Very shallow, very weedy			Pounds per acre			Pounds per acre subdivision, 1—6 ft.		Date collections
Lake	Acreage low water 1901	Max. depth Hav., 8 ft.	Open water over 6 ft.	1—6-ft. zone	All stations	No vegetation	Vegetation	
Duck—Dennis	260 a.	4 ft.	.....	110.3 *5**	....	....	110.3 *5*	1914
Crane	910 a.	3½ ft.	.....	79.0 *5*	....	....	79.0 *5*	1915
Average	.....	.....	.....	94 *10*	94 *10*	....	94 *10*	
Class V. Dead timber and brush								
		4 ft.	.....	160.9 *6*	....	....	160.9 *6*	1914
		3½ ft.	.....	202.4 *10*	....	....	202.4 *10*	1915
Average	.....	.....	.....	187 *16*	187 *16*	....	187 *16*	

* The Italic figures give the number of collections.

3. General Average Valuation

A simple average (without weighting to compensate for irregularity in distribution of collections within different lake classes) of the total of 266 bottom collections of 1914—1915 from the five classes of lakes and backwaters (including dead timber and brush areas) figures out at 402 lbs. per acre. Since the general average of 848 lbs. per acre for the Class II lakes (Quiver, etc.) applied to but 620 acres at the low water of 1901, while the average of 352 lbs. per acre for the Class I lakes covered 3,390 acres at the same gage, it is evident that a simple average of this sort is unfair and likely to be unduly high. As we have not complete acreage figures for different depths at recent gages prevailing in midsummer, and lack, in particular, exact figures on the dead timber acreage, a close general average of all the lakes and backwaters studied in the two years, based on accurate acreage weightings, can not now be figured. If we assume, however, that on the average the expansion in lake acreage between 4.2 and 8 feet, Havana, is about the same in all of the first four classes of lakes except Class II, we shall not go far wrong in weighting the class average of I to IV, excluding the dead timber and brush areas, with the low-water acreage for 1901. The general bottom-fauna average for Classes I—IV, inclusive, figures out in this way at *285* lbs. per acre. If, again, we assume that the usual ratio of adjacent dead-timber acreage to the total acreage of lakes and backwaters at gage 8 feet, Havana, is about the same as in Thompson Lake (around 30%, estimated), and weight the Class I—IV average (285 lbs.) and the Class V average (187 lbs., dead timber and brush areas) with "per cent." acreage figures on this basis, we obtain a general average of bottom fauna for the two years, for all classes of lakes and backwaters, all depths, of *255* lbs. per acre, or almost exactly the general river average for 180.5 miles below Chillicothe (261 lbs.), but only about one third of the all-zone river average for the 59.3 miles between Copperas Creek and Lagrange dams (705 lbs.).

ILLINOIS VALLEY LAKES, BOTTOM FAUNA, 1914—1915

Class	Acreage low water 1901	Max. depth Hav., 8 ft.	Pounds per acre			Pounds per acre subdivision, 1—6 ft.		Date collections
			Open water over 6 ft.	1—6-ft. zone	All stations	No vegetation	Vegetation	
I Deep bottom-land type	3,390	9 ft.	222 *53**	441 *78*	352 *131*	696 *21*	347 *57*	1914—1915
II Deep, sand-beach type	620	12 ft.	1,667 *27*	251 *37*	848 *64*	....	251 *37*	1914—1915
III Shallow, weedy	1,530	5 ft.	.....	57 *45*	57 *45*	....	57 *45*	1914—1915
IV Very shallow; very weedy	1,170	4 ft.	.....	94 *10*	94 *10*	....	94 *10*	1914—1915
V Dead timber and brush	?	4 ft.	.....	187 *16*	187 *16*	....	187 *16*	1914—1915
Average† I—IV	6,710	....	.....	.....	285 *250*			
Average‡ I—V	....	....	.....	.....	255 *256*			

* The Italic figures give the number of collections. † Acreage-weighted. ‡ Weighted on per cent. basis.

4. Composition of the Bottom Fauna

The proportion of Mollusca to associated animals in the lake collections of 1914—1915 did not run so uniformly high as in the river series of 1915. The Mollusca percentages are highest in the open water of the deeper lakes of Classes I and II, where they run from 84 to 96%. In the weedy zones (1—6 feet) of the deeper lakes the Mollusca percentages were noticeably lower (77%). In the shallower weedy lakes of Classes III and IV the insects and small Crustacea are much more abundant relatively, and the Mollusca ratios drop to 36 and 50%.

Per Cent. Mollusca by Weight (to Total Weight of Collections), Lakes, 1914—1915

	Zone over 6 feet open water	1—6 ft., no vegetation	1—6 ft., vegetation
Class I	84.1	89.8	77.8
Class II	96.8	....	77.5
Class III	....	....	50.7
Class IV	....	....	36.4
Class V	....	....	79.7

The snail fauna of the lakes, like the insect fauna, presents in the average somewhat greater variety than that of the river. Viviparidae made up the largest percentage of the Mollusca totals in the deeper lakes of Classes I and II. In the shallower weedy lakes and in the dead timber areas the ratios of Viviparidae were lower. The smaller snail fauna (smaller Gastropoda, Sphaeriidae) less rarely than in the river consisted almost exclusively of Sphaeriidae—the Valvatidae and Amnicolidae being well represented in most of the lakes studied, and exceeding Sphaeriidae in some cases, in the shallower weedier lakes, both in numbers and weight.

Further details of the composition of the lake bottom-fauna are shown in the detail tables at the end.

Per Cent. of Viviparidae, by Weight, to Total Weight of all Mollusca, Lakes, 1914—1915

	Zone over 6 ft. open water	1—6 ft., no vegetation	1—6 ft., vegetation
Class I	56%	85%	86%
Class II	99%	....	88%
Class III	....	....	62%
Class IV	....	....	61%
Class V	....	....	77%

ILLINOIS VALLEY LAKES, 1914—1915, BOTTOM FAUNA
POUNDS PER ACRE

I. Deep Bottom-land Type. (Zone over 6 feet)

Lake	No. collections	Large Viviparidae etc.	Sphaeriidae etc.	Insects etc.	Total	Per cent. Mollusca
Clear—Mud, 1915	8	17.1	186.8	11.7	215.6	94
Liverpool, 1915	6	24.3	96.7	21.2	142.2	85
Thompson, 1914	8	76.5	140.0	94.2	310.7	69
Thompson, 1915	8	413.9	64.6	18.1	496.6	96
Dogfish, 1914	3	8.0	3.1	12.3	23.4	47
Dogfish, 1915	12	67.1	18.5	66.4	152.0	56
Sangamon, 1915	10	51.2	41.4	14.0	106.6	86
Average	53	104.6	82.2	35.2	222	84.1%

ILLINOIS VALLEY LAKES, 1914—1915, BOTTOM FAUNA
POUNDS PER ACRE

I. Deep Bottom-land Type. (1—6-ft. Zone. No Vegetation)

Lake	No. collections	Large Viviparidae etc.	Sphaeriidae etc.	Insects etc.	Total	Per cent. Mollusca
Thompson, 1914	10	687.1	80.3	135.8	903.2	85
Thompson, 1915	7	610.5	24.9	12.2	647.6	98
Sangamon, 1915	4	145.3	109.5	10.2	265.0	96
Average	21	558.3	67.3	70.6	696	89.8%

I. Deep Bottom-land Type. (1—6-ft. Zone. Vegetation)

Clear—Mud, 1915	12	121.7	110.7	17.7	250.1	93
Liverpool, 1915	9	117.0	4.2	28.2	149.4	85
Thompson, 1914	16	210.0	28.4	193.1	431.5	55
Thompson, 1915	12	481.9	10.0	20.4	512.4	95
Dogfish, 1914	5	336.0	19.1	42.4	397.5	89
Dogfish, 1915	3	none	7.3	126.9	134.2	5
Average	57	233.9	36.1	77.0	347	77.8%

ILLINOIS VALLEY LAKES, 1914—1915, BOTTOM FAUNA

POUNDS PER ACRE

II. Deep, Sand-Beach Type. (Zone over 6 feet)

Lake	No. collections	Large Viviparidae etc.	Sphaeriidae etc.	Insects etc.	Total	Per cent. Mollusca
Quiver, 1914	15	2,754.6	2.9	47.5	2,805.0	98
Quiver, 1915	3	800.0	none	3.1	803.1	99
Matanzas, 1915	9	none	40.6	18.0	58.6	69
Average	27	1,619.2	15.1	32.7	1,667	96.8%

II. Deep, Sand-Beach Type. (1—6-ft. Zone. Vegetation)

Quiver, 1914	17	329.7	33.4	25.2	388.3	93
Quiver, 1915	14	35.5	9.3	113.9	158.7	28
Matanzas, 1915	6	58.4	9.6	9.9	77.9	87
Average	37	174.3	20.4	56.2	251	77.5%

ILLINOIS VALLEY LAKES, 1914—1915, BOTTOM FAUNA
POUNDS PER ACRE
III. Shallow, Weedy Type. (Depth 1—5 ft.)

Lake	No. collections	Large Viviparidae etc.	Sphaeriidae etc.	Insects etc.	Total	Per cent. Mollusca
Flag, 1914	3	none	25.7	45.2	70.9	63
Flag, 1915	15	5.0	none	22.9	27.9	18
Seebs, 1914	7	14.0	15.5	94.5	124.0	24
Seebs, 1915	8	18.5	1.8	5.6	25.9	78
Stewart, 1915	12	41.0	24.4	8.4	73.8	88
Average	45	18.0	10.9	28.1	57	50.7%

ILLINOIS VALLEY LAKES, 1914—1915, BOTTOM FAUNA
POUNDS PER ACRE
IV. Very Shallow, very Weedy Type. (Depth 1—4 ft.)

Lake	No. collections	Large Viviparidae etc.	Sphaeriidae etc.	Insects etc.	Total	Per cent. Mollusca
Duck—Dennis, 1914	5	none	12.4	97.9	110.3	11
Crane, 1915	5	42.0	14.3	22.7	79.0	71
Average	10	21.0	13.3	60.3	94	36.4%

V. Dead Timber and Brush Areas. (Depth 1—4 ft. Vegetation)

Vicinity Havana, 1914	6	29.8	87.1	44.0	160.9	72
Vicinity Havana, 1915	10	167.5	1.3	33.6	202.4	83
Average	16	115.8	33.4	37.5	187	79.7%

The Weed-Fauna of the 1—4-foot Zone of the Illinois Valley Lakes, and the Combined Bottom- and Weed-Fauna Average, August—October, 1914

1. Weed Fauna of the Lakes near Havana

In the autumn of 1914 a series of quantitative collections of the small invertebrates attached to and scattered between the leaves and stems of the denser growths of coarse vegetation about the margins of the bottom-land lakes near Havana, in depths 1 to 4½ feet, were made at seven stations. These collections were made by inclosing the tops of the plants in a large bucket, lowered about them to a depth of about 9 inches, cutting off the stems a little below the 9-inch level, shaking them out thoroughly in the water obtained by righting the bucket, and then passing the water saved through a fine sieve. Though these collections represent but a fraction of the total "weed fauna", omitting the small insects and other animals occurring between the bottom and the lower limit of the bucket hauls (a distance of 1 to 3 feet), the average valuations obtained in this way were very much above the average *bottom* valuations from the same lakes in any zone, with the single exception of a few hauls from the bottom of the Quiver Lake "channel" in 1914. The general average for the seven stations was in fact 2,118 lbs. per acre, or more than eight times the general average of bottom fauna for the five classes of lakes and backwaters between the head of Clear Lake and Beardstown studied by us in 1914 and 1915 (255 lbs.).

The smaller snails (Amnicolidae, Physidae, and Valvatidae, principally) formed about 50% of the average total by weight. The approximate half of the collections made up of insects (larvae and nymphs) consisted principally of immature Odonata (Agrionidae and small Libellulidae). The only large snails were a few adult *Planorbis trivolvis*, the great bulk of the material being of quite small size and easily available, in that respect, for use as food by young to half-grown as well as adult fishes.

2. Combined Average Valuation of the Bottom- and Weed-Fauna Stocks, and Total Stocks in the Acreage

For the purpose of calculating a general average, and also the total stocks, both of the bottom and weed animals, for the entire lake and other backwater acreage between Copperas Creek dam and Lagrange (approximately 52,700 acres at 8 feet, Havana—the average gage in July—October, 1910—1914), I have assigned the general bottom-fauna average of the twelve lakes studied (255 lbs.) to the entire acreage, as with no levees, and the weed-fauna average of the lakes in the immediate neighborhood of Havana (2,118 lbs.) to the approximate 29,700 acres with depths under 4 feet in the district. An acreage-weighted general average figured in this way stands at 1,447 lbs. per acre, or at

LAKES, VICINITY HAVANA, 1914, WEED FAUNA (UPPER 9 INCHES)

POUNDS PER ACRE

Lake	Number collections	Depth feet	Viviparidae etc.	Amnicolidae Valvatidae Physidae	Insects etc.	Total	Per cent. Mollusca	Date of collection
Between Flag and Thompson	1	2	.....	2,164.1	429.0	2,593.0	83	Oct. 6
Head of Flag	1	1½	.....	481.4	2,036.2	2,517.6	19	Oct. 7
Middle of Duck	1	4	.....	2,421.7	86.2	2,507.9	96	Oct. 2
Foot of Thompson	1	3½	.....	534.6	1,953.6	2,488.2	21	Aug. 12
Foot of Thompson	1	2½	.....	991.4	1,314.0	2,305.4	43	Aug. 14
Middle of Flag	1	4	.....	560.3	705.0	1,265.3	44	Oct. 6
Foot of Thompson	1	4½	.....	320.4	833.4	1,153.8	27	Aug. 14
Average	7	...	.....	1,067.7	1,051.0	2,118	50.8%	

more than twice the all-zone river average for bottom fauna only in the same distance (705 lbs.), and at more than 5½ times the average figures for bottom fauna only in the lakes and other backwaters between the two dams in 1914 and 1915 (255 lbs.).

The total stocks in the entire 52,760 acres of lakes and ponds (acreage as with no levees, substantially same as 1908 rather than 1914—1915, for purpose of comparison with fish yields of that year), 76,358,400 lbs. is more than 10 times the total stocks in the 59.3 miles of river opposite (6,988,103 lbs. for 26,700 acres). Of the total, 13,453,800 lbs., or 17.6%, represents the bottom animals of the full acreage; and 62,904,600 lbs., or 82.3%, represents the small weed animals of the upper 9 inches only, in the rather more than 50% of the total acreage within the 4-foot line.

Bottom- and Weed-Fauna Stocks, Lakes, Copperas Creek Dam to Lagrange (59.3 miles)

	Approx. acreage 8 ft., Havana (No levees)	Average valuation* pounds per acre 1914—1915	Total stocks for acreage in first column†	Per cent. of total
Bottom fauna stocks—all depths	52,760 a.	255	13,453,800	17.6%
Weed fauna stocks—1—4 ft.	29,700 a.	2,118	62,904,600	82.3%
Bottom and weed stocks	52,760 a.	1,447	76,358,400	

The Bottom- and Weed-Fauna of the Littoral Zone of the Deep Glacial Lakes of Northeastern Illinois, August—October, 1916

1. Bottom Fauna

The general average of 119 mud-dipper collections from the zone of 1—7 feet in eight of the deep glacial lakes of northeastern Illinois in August—October, 1916, was only 82.8 lbs. per acre. The six isolated lakes studied (Deep, Cedar, Zurich, Crystal, Long, and Sand lakes) showed the better average (105.8 lbs.), while the two large lakes (Fox and Pistakee) directly open to the channel of Fox River averaged only 54.2 lbs. Sparse vegetation, principally species of Potamogeton, with some Chara, chiefly within the 3-foot line, were present at most of the collecting stations. The bottom varied from sand, gravel or sandy mud, to soft black mud or yellow clay. On the windward side (southeast or west) of most of these lakes there is a more or less sterile clay zone with very

* Based on data from 12 lakes representing around half of the total acreage.
† Equals approximately that of 1908. (Table originally made for comparison with 1908 fish yields.)

scanty vegetation, or none at all, lying between the weedy shore zone and the deep open water, part of it sometimes extending within the 7-foot line.

Valuations considerably better than the average were obtained in restricted areas with more nearly uniform bottom in four of the isolated lakes, the average for clay bottom overlaid with fine decayed vegetation, in Deep Lake being 320 lbs.; for sand and clay, in Cedar Lake, 251 lbs.; for gravel and sand, in Deep Lake, 220 lbs.; and for gravel and sand, in Lake Zurich, 212 lbs.

In its composition the littoral bottom-fauna of these lakes differs most strikingly from that of the Illinois Valley bottom-land lakes in the relatively much lower percentages of Mollusca. Snails made up only

LAKES, NORTHEASTERN ILLINOIS, AUGUST—OCTOBER, 1916, BOTTOM FAUNA
POUNDS PER ACRE
LITTORAL ZONE, 1—7 FEET. SOME VEGETATION

Lake	Number of collections	Large Viviparidae etc.	Sphaeriidae etc.	Insects etc.	Total	Per cent. Mollusca
Deep	7	....	39.8	169.0	208.8	19
Cedar	24	....	24.2	135.6	159.8	15
Zurich	13	9.9	10.0	49.2	69.1	23
Crystal	6	....	16.0	40.4	56.4	28
Long	6	....	1.7	50.7	52.4	3
Sand	10	....	0.6	13.1	13.7	4
Average	66	1.8	16.7	87.1	105.8	17.4%
Pistakee	29	10.8	26.0	42.6	79.4	46
Fox	24	2.3	3.6	18.0	23.9	24
Average*	53	6.9	15.8	31.4	54.2	41.8%

* General (simple) average of 8 lakes (119 collections)=82.8 pounds per acre.

17.4% of the average weight of the hauls at 66 stations in the six isolated lakes; and only 41.8% in the two lakes traversed by the Fox River channel. The snails belonged almost entirely to the smaller-sized species, the larger Pleuroceridae and Viviparidae occurring only very rarely and in small numbers in the hauls. The most abundant families were the Sphaeriidae, Amnicolidae, Valvatidae, and Physidae. The most important insects, measured by weight, were the Trichoptera (caddis-flies), Chironomidae, and large Ephemeridae (May-flies).

(A more complete report on these collections, including also the dredgings in deep water, is being planned for publication later.)

2. Weed Fauna

In August, 1916, we found the shore vegetation of the isolated glacial lakes so generally thin and sparse, as compared with the dense growths of Potamogeton and Ceratophyllum in the Illinois River bottom-land lakes, that it was practically impossible to employ the bucket method of collecting the weed animals used at Havana in 1914. Along the north shores of Pistakee and Nippersink lakes, however, beds of mixed Potamogeton, Myriophyllum, and Ceratophyllum were not uncommon that were fully as dense and that carried not far from as rich a fauna as that of such lakes as Flag and Thompson. The average for the upper 9 inches at two stations in Pistakee and Nippersink lakes in August, 1916 (1,665 lbs. per acre), was only 26% less than the average of the seven weed-fauna stations in the vicinity of Havana in 1914 (2,118 lbs.). Both insects and mollusks constituted an almost insignificant part of the totals, 85% of the weight in one case, and 95% in the other being made up of a single small crustacean—the little fresh-water shrimp, *Hyalella knickerbockeri*. (Table, p. 436.)

Comparison with Outside Bottom- and Weed-Fauna Valuations

1. Bottom- and Weed-Fauna of Oneida Lake. (Baker, 1918)

In the Lower South Bay of Oneida Lake, New York, in 1916, Baker found the richest bottom-fauna within the 6-foot contour. Averaged by weight*, in pounds per acre, sand bottom showed the highest valuations, 143 sixteen square-inch units examined, averaging 387 lbs. Gravel bottom, with 207 lbs., clay bottom, with 188 lbs., and sand and clay, with 210 lbs., were well under sand bottom in richness, but were all much richer than the mud bottom over 6 feet. The mud bottom within the 6-foot line averaged for 27 units 230 lbs. per acre. These valuations much

* Rough, approximate valuations, by present author, from Baker's figures per unit of 16 square inches, on same general basis followed in valuation of Illinois River and lake data, 1914—1916. Average adult size of some of the snails estimated by Mr. Baker. Chironomidae and larvae of Trichoptera lumped and averaged at a round valuation about the average of those of northeastern Illinois glacial lakes.

LAKES, NORTHEASTERN ILLINOIS, 1916. WEED FAUNA (UPPER 9 INCHES)

POUNDS PER ACRE

Lake	Number collections	Depth feet	Viviparidae etc.	Amnicolidae Valvatidae Physidae etc.	Hyalella, insects, etc.	Total	Per cent. Mollusca	Per cent. insects	Per cent. Hyalella	Date
Pistakee north side, upper end	1	3½	....	81.1	2,330.0	2,411.2	3	2	95	Aug. 17
Nippersink north side	1	3½	....	36.0	863.0	899.0	4	11	85	Aug. 18
Average	....	...	....	....	.....	1,655				

exceed the average figures obtained by us in 1916 in the same depth zone in the isolated glacial lakes of northern Illinois (105 lbs.), but do not average much if any better than the best littoral areas in Deep and Cedar lakes (Deep Lake, gravel bottom, 220 lbs., clay and rotten vegetation, 320 lbs.; Cedar Lake, sand and clay bottom, 251 lbs.). They compare very well with the all-depth average (one to eleven feet) for the Illinois Valley lakes of all classes in 1914 and 1915 (255 lbs. per acre), but are exceeded by the general average of bottom fauna only in the 1—6-foot zone of our Class I lakes in the Havana district (441 lbs.); and are far surpassed by the figures for the 1—3- and 4—7-foot zones of the Illinois River between Copperas Creek dam and Havana (1—3-foot zone, 919 lbs.; 4—7-foot zone, 1,960 lbs.). The ratio of Mollusca to the total weight of all animals averaged much higher (38% to 64%) than in the glacial lakes of northern Illinois, but was far under the ratios found in the Illinois River and in the lakes near Havana.

Bottom Fauna of Oneida Lake, 1—6-foot Zone
pounds per acre (our valuations)

	Mollusca	Associated animals	Total	Per cent. Mollusca
Sand bottom	251.3	138.3	389	64
Mud bottom	96.9	133.5	230	42
Sandy clay	81.4	129.3	210	38
Gravel	139.4	68.2	207	67
Clay	75.3	112.7	188	40

While Baker found in Oneida Lake, in a few situations, a weed fauna (total, picked by hand from plants removed from the water) that approached in valuation his bottom-fauna averages for the littoral zones, the average productivity indicated ran very low, and even his heaviest collections (57 to 207 lbs. per acre, our valuations) were far below those obtained by us in the lakes of the Illinois Valley near Havana (2,118 lbs. average) or in the thick Potamogeton and Ceratophyllum beds of Nippersink and Pistakee lakes (1,655 lbs.). Baker's best figures were obtained in the Potamogeton and Myriophyllum, and the bulk of the collections by weight was made up of snails.

2. Bottom Fauna of Lake Mendota. (Muttkowski, 1918)

Average valuations in pounds per acre for the 0—1- and 1—3-meter zones obtained by Muttkowski in Lake Mendota in 1914 and 1915 (60 and 64 lbs. respectively) are slightly higher than our averages of 1916 from the 1—6-foot zone of Fox and Pistakee lakes (54 lbs.), but are well under the average for the six isolated glacial lakes (105 lbs.). Mollusca formed only 4% of the total average weight in the 0—1-meter areas, and 14% in the 1—3-meter zone. The most important groups of animals as measured by weight were the larvae of Chironomidae and Trichoptera.

Bottom fauna of Lake Mendota, Wisconsin. 1—3 meters pounds per acre (our valuations)

	Mollusca	Others	Total	Per cent. Mollusca
0—1 meter	2.59	57.37	60	4
1—3 meters	9.40	55.12	64	14

3. Marine Bottom-Fauna. Valuations, Denmark (Petersen, 1911—1918)

The marine bottom-fauna valuations, by rough weight, obtained by Petersen 1910 to 1916 included the shells of Mollusca and echinoderms, and require reduction by percentages that probably range at least 33 to 75%. His average valuations for large areas all concern the bottom fauna outside the 6-meter limit, in depths ranging from 10 meters upwards. The average valuation obtained for the Thisted Bredning, years 1910—1916, with an area of 65,000,000 m.^{2} (= 16,055 acres) was 3,298 lbs. per acre, rough weight, which would figure down by the percentages mentioned to 800 to 2,200. The Nissum Bredning averages for 110,000,000 m.^{2} (27,170 acres) was somewhat lower, 2,418 lbs., which would stand with deductions of 33 and 75% at 600 or 1,600 lbs.

Petersen's figures for restricted Mytilus and Modiola (a mollusk related to Mytilus) communities—167,556 and 92,036 lbs. per acre, or 83 and 46 tons, respectively, the first in 2-meters depth, the second in 28 meters—by far exceed anything that has been reported elsewhere, so far as we know, for sea or land crops. The figures in the case of the Mytilus haul are equivalent to 552.9 ounces per square yard, or to 0.42 ounce per square inch of bottom area: and those for Modiola, to 303.7 ounces per square yard, or 0.23 ounce per square inch. These figures compare with about 10 ounces per square yard (3,029 lbs. per acre), the net average weight* of the Illinois River channel collections of 1915 between

* Shells of Mollusca deducted.

Copperas Creek dam and Havana. The Mytilus taken by Petersen, as shown by the photographed heaps as they fell out of the bottom sampler, were lying upon each other on the sea bottom.

MARINE BOTTOM FAUNA VALUATIONS (PETERSEN, 1911—1918)
AVERAGES, POUNDS PER ACRE*, LARGE AREAS

	Depth	Acres	Pounds per acre rough weight	Net weight†—after deductions 33 and 75%
Thisted Bredning	over 10 m.	16,055	3,298	800—2,200
Nissum Bredning	over 10 m.	27,170	2,418	600—1,600

PETERSEN'S FIGURES FOR RESTRICTED COMMUNITIES, COMPARED WITH BEST ILLINOIS-RIVER CHANNEL, 1915

	Depth	Pounds per acre	Ounces per square yard	Ounces per square inch	
Mytilus community	2 m.	167,556	552.9	0.42	Rough weight
Modiola community	28 m.	92,036	303.7	0.23	Rough weight
Average Illinois-river channel, Copperas Creek dam to Havana	....	3,029	10	....	Shells deducted

The Food of certain Small Bottom-Invertebrates in the River Channel at Havana and the General Composition of the Detritus

The results of microscopical examination of the stomach and gut contents of a number of the commoner Gastropoda, Sphaeriidae, insect larvae, and others of the small bottom animals of the channel opposite Havana in July, 1914, suggested that settled limnetic plankton plays a more important role in the food of the bottom fauna than seems to be generally recognized. The studies made call for a subdivision of the commoner small bottom-animals at that place into two main groups; the one depending principally upon plankton, and the other more largely upon old detritus, though containing species that make considerable use of

* Pounds per acre calculated by us from Petersen's figures in grams per 0.25 m.²
† Our estimates.

plankton also. The specimens that fall clearly into the group of plankton-feeders represented a rather wide range of families, including Sphaeriidae (as represented by *Sphaerium striatinum*); young Unionidae, about one year old; Bryozoa *(Urnatella gracilis);* Trichoptera (larvae of Hydropsyche species); Chironomidae (unidentified red larvae); and Planaria. The stomachs of the Sphaeriidae and young Unionidae, though containing principally settled limnetic plankton, held also small amounts of fine dead detritus, as well as many living bacteria, apparently taken in with the latter or with dead planktonts. The insect larvae (caddis and Chironomidae) had enjoyed a clean feed of settled plankton, some of it still alive when eaten. Some living bacteria were seen in the stomachs of the caddis larvae. Species whose stomachs contained nothing but dead detritus included a small Asellus and several tubificid worms. The larger snails of the family Viviparidae (*Campeloma subsolidum* and *Vivipara contectoides*) had eaten large quantities of loose detritus and what appeared to be slime-clotted silt and organic detritus particles such as is commonly found as a thin coating on the shells of the snails themselves and on other hard objects in the mud. Living bacteria, presumably putrefactive or fermentative types, were exceedingly abundant in the material in their stomachs. In small specimens of Vivipara and Campeloma, on the other hand, diatoms and Chlorophyceae from the settling limnetic plankton were not much if any less abundant than old dead detritus. Attached incrusting algae (Pleurococcus and Palmella types) were present in the stomachs of all Viviparidae examined.

In going through samples of the loose bottom-ooze taken with the mud-sucker (see Figure 6, page 372), I was struck with the fact that limnetic plankton, principally diatoms and Chlorophyceae, was, next after the flaky particles of decayed vegetable or animal matter that makes up the dead organic detritus, the most abundant edible element in the ooze, as far as could be determined, being decidedly more important in bulk than normal bottom Protozoa and Rotifera. While bottom Ostracoda were noted in the ooze they were relatively very rare, and limnetic Copepoda, Cladocera, and Rotifera were represented only by fragments or nearly whole carapaces or other chitinous parts.

The enormous numbers of bacteria seen swarming in and among the flaky honeycombed particles of dead organic matter, and inside the bodies of recently dead planktonts, suggest that these minute organisms are themselves not an unimportant part of the food supply of both the plankton- and detritus-eating bottom-animals. Both bacteria and minute pale flagellates and ciliates were also very abundant in the interstices of the slime-bound silt and detritus scum that envelops the upper surface of the shells of a large portion of the living and dead snails. That this material on their own backs is used as food by their fellows is apparently proven by its presence in the stomachs as well as by the numerous tracks of radulae identified in the mantle of scum on the backs of living Vivipara and Campeloma examined.

FOOD OF BOTTOM INVERTEBRATES, ILLINOIS RIVER CHANNEL, HAVANA, JULY, 1914
FOOD FOUND IN STOMACHS OF PLANKTON FEEDERS

Species examined	1. Fine organic detritus (dead matter)	2. Bacteria in detritus or dead plankton	3, 4. Settling limnetic and normal bottom plankton			5. Attached micro-organisms
			Diatoms	Algae	Protozoa Rotifera etc.	
Sphaerium striatinum	Trace	† †	Cyclotella † Navicula † Melosira † etc.	Scenedesmus Coelastrum	Chlamydomonas colorless flagellates* Synchaeta pectinata	
Lampsilis parvus, ½ inch	Trace	† † †	Cyclotella † Navicula † Melosira † etc.	Pediastrum	Chlamydomonas colorless flagellates and ciliates.*	

NOTE.—†††=very abundant; ††=abundant; †=common.

* Normal protozan inhabitants of the thin bottom-ooze.

FOOD OF BOTTOM INVERTEBRATES, ILLINOIS RIVER CHANNEL, HAVANA, JULY, 1914
FOOD FOUND IN STOMACHS OF PLANKTON FEEDERS

Species examined	1. Fine organic detritus (dead matter)	2. Bacteria	3. Settling limnetic plankton			5. Attached micro-organisms
			Diatoms	Algae	Protozoa Rotifera etc.	
Larva of caddis-fly (Hydropsyche sp.)	None	Some	Cyclotella Melosira Navicula etc.	Scenedesmus †	Chlamydomonas †	
Chironomid larva ½ inch, red	None	....	Many species	Scenedesmus †		
Planarian	None	A few	Melosira cells	Coelastrum	Chlamydomonas	
Urnatella gracilis	None	....	Navicula Cyclotella Melosira cells Fragilaria cells Surirella	Scenedesmus	Eudorina Pandorina	

NOTE.—The dagger = common.

FOOD OF BOTTOM INVERTEBRATES, ILLINOIS RIVER CHANNEL, HAVANA, JULY, 1914

FOOD FOUND IN STOMACHS OF DETRITUS FEEDERS

Species examined	1. Fine organic detritus (dead matter)	2. Bacteria (in detritus)	3. Settling limnetic plankton			5. Attached micro-organisms
			Diatoms	Algae	Protozoa Rotifera etc.	
Campeloma subsolidum	† † †	† †	Navicula Synedra Cyclotella Melosira †	Pediastrum Coelastrum Scenedesmus †	Chlamydomonas † Pandorina	Pleurococcus? †
Vivipara contectoides	† †	† †	Navicula Synedra Cyclotella Melosira †	....	....	Pleurococcus? † Rhizoclonium
Asellus aquaticus	† †	† †				
Tubificid worm	† † †	† † †				

NOTE.—††† = very abundant; †† = abundant; † = common.

The Nitrogen, Organic Carbon, and other Oxidizable Matter in the Bottom Muds of the River and Lakes below Chillicothe, 1913—1914

1. Bottom Muds of the Illinois River Channel, 1913

Mud samples taken in the Illinois River channel between Chillicothe and Kampsville in March and July—October, 1913, showed a rather wide variation in the amounts of nitrogen present, as expressed in terms of percentage of dry matter, but both in early spring and late summer agreed in showing a higher average above than below Havana. In percentage figures, as stated, five samples from above Havana, all months taken together, averaged 0.306% nitrogen, or 61% richer than the five samples taken on approximately the same dates at stations below Havana, which averaged 0.189%. A lesser actual difference in average nitrogen content is shown for the stations above and below Havana, when we take into account the specific gravity and the moisture percentages of the samples and calculate average values of nitrogen by weight for a given area to a depth (3 inches) supposed to approximate the average depth of cut into the soft bottom by the dipper in taking the samples. The average number of pounds of nitrogen to the acre, figured in this way, was 1,918 for the stations above Havana; and only 26% less, or 1,417 lbs. per acre for the stations between Lagrange dam and Kampsville, in which the specific gravity was visibly higher and the moisture-content lower.

The organic carbon per acre figures out, both above and below Havana, at about 8 times the nitrogen, the averages standing at 14,111 lbs. per acre for the stations above and 11,322 lbs. for the stations below Havana. The total oxidizable matter (which includes both the nitrogen and the organic carbon, as well as various other substances, some of them of a mineral nature), figured in the same way, averaged 48,345 lbs. per acre to a depth of 3 inches in the river channel above Havana, and 31,869 lbs. per acre below Havana.

Compared with the stocks of nitrogen and total oxidizable matter (dry weight) in the muds either above or below Havana, the total acre-poundages of dry matter or nitrogen represented by the bottom invertebrate population of July—October, 1913, are extremely small, however liberally figured. Taking the average bottom-fauna stocks of the river between Chillicothe and Havana (the richest section) as 555 lbs. per acre (see table, page 412), and assuming a dry-matter content of about 10% and a percentage of nitrogen to dry matter of 7%, the dry weight of the average stock of bottom fauna on one acre would stand at 55 pounds, or about 1/900 of the dry weight of the total oxidizable matter per acre in the channel mud of that reach, and the contained nitrogen at less than 4 pounds, or about 1/500 of the total nitrogen per acre.

NITROGEN, ETC., IN MUD, ILLINOIS RIVER CHANNEL, 1913. (AVERAGES)

Reach	Specific gravity	Moisture per cent.	Wet weight 1 liter	Dry weight 1 liter	Nitrogen Mar.—Oct.	Organic carbon July—Oct.	Total oxidizable matter March
	1.55	40.2	1,550 g.	927 g.			
Chillicothe to Havana	Per cent. (terms dry matter)				0.306	2.41	7.71
	Pounds per acre (approximately) to depth 3 inches				1,918	14,100	48,340
	1.67	33.6	1,670	1.108			
Lagrange dam to Kampsville	Per cent. (terms dry matter)				0.189	1.51	4.25
	Pounds per acre (approximately) to depth 3 inches				1,417	11,300	31,860

2. Bottom Muds of the Lakes between Copperas Creek Dam and Beardstown

Comparison of samples from the central portions of eleven lakes between the head of Clear Lake and Browning, May—October, 1914, on the dry-weight percentage basis shows the shallow weedy lakes highest in bottom nitrogen. The average of Flag, Seebs, and Stewart lakes (Class III lakes) in terms of percentage of dry matter, was 0.39%, compared with an average of 0.27% for seven of the deeper, more open lakes of Classes I and II; and with 0.26% for Crane Lake—a lake of the very shallow, very weedy type. The general average of all of the 19 mid-lake samples from eleven lakes of 4 of the five classes (0.32%) was somewhat more than the average for the river channel stations above Havana (0.306%) and nearly twice the river average below Havana (0.189%). The general average of organic carbon in mid-lake samples was 3.89%, comparing with 2.41% for the river channel above Havana, and with 1.51% for the channel below Havana. In organic carbon as in nitrogen, the shallow weedy lakes of Classes III and IV (with 4.30% and 5.19%) averaged well above the deeper lakes of Classes I and II (with 3.67% and 3.09%).

Both in Thompson and Quiver lakes, May—October 1914, the nitrogen and organic carbon figures were considerably highest in samples from the shallower water, the percentages of average difference as between samples from under and over 6 feet in depth amounting in the case of the nitrogen to over 30%, in both Thompson and Quiver lakes, and in the case of the organic carbon to 15% in Thompson and to 52% in Quiver.

Nitrogen and Organic Carbon in Muds, Thompson and Quiver Lakes, May—October, 1914

	Nitrogen Per cent. (in terms of dry matter)		Organic carbon Per cent. (in terms of dry matter)	
	Thompson Lake	Quiver Lake	Thompson Lake	Quiver Lake
Depth over 7 feet	0.325	0.320	4.83	3.46
Average	*8**	*4*	*8*	*4*
Depth 1—6 ft.	0.428	0.440	5.56	5.27
Average	*7*	*4*	*7*	*4*
All depths	0.373	0.400	5.17	4.67
Average	*15*	*4*	*15*	*4*

* The Italic figures give the number of samples.

NITROGEN, ETC., IN MUD OF ILLINOIS VALLEY LAKES, MAY—OCTOBER, 1914
SAMPLES FROM MIDDLE, IN DEEPEST WATER
PER CENT. IN TERMS OF DRY MATTER

	Lake	Samples	Nitrogen	Organic carbon
I. Deeper bottom-land lakes	Clear—Mud	2	0.23	2.93
	Liverpool	1	0.29	2.52
	Thompson	4	0.32	4.83
	Dogfish	1	0.30	3.46
	Sangamon	1	0.22	4.86
	Average (5 lake averages)	..	0.27	3.72
II. Deeper sand-beach lakes	Quiver	4	0.32	3.46
	Matanzas	1	0.24	2.73
	Average (2 lake averages)	..	0.28	3.09
III. Shallow, weedy lakes	Flag	1	0.52	5.48
	Seebs	1	0.35	3.78
	Stewart	1	0.31	3.66
	Average	..	0.39	4.30
IV. Very shallow, very weedy lakes	Crane	1	0.26	5.19
	General average.....		0.32	3.89

NITROGEN, ETC., IN BOTTOM MUDS, 1913—1914,
ILLINOIS RIVER CHANNEL AND LAKES IN VICINITY OF HAVANA

	Nitrogen		Organic carbon		Total oxidizable matter	
	*	†	*	†	*	†
River channel Chillicothe to Kampsville	.247	100	1.87	100	6.32	100
River channel, above Havana	.306	123	2.41	128	7.71	121
River channel, below Havana	.189	76	1.51	80	4.25	67
Eleven lakes, vicinity of Havana, middle	.320	129	3.87	206		
Thompson Lake, middle	.325	131	4.83	258		
Thompson Lake, shore, 1—6 ft.	.428	173	5.56	297		
Thompson Lake, all depths	.373	151	5.17	276		
Quiver Lake, middle	.320	129	3.46	185		
Quiver Lake, shore, 1—6 ft.	.440	178	5.27	281		
Quiver Lake, all depths	.400	161	4.67	249		

The Plankton and other Limnetic Oxidizable Matters carried by the Illinois River Channel at Chillicothe and Havana, 1909—1914

1. STOCKS OF PLANKTON CARRIED PAST HAVANA SEPTEMBER, 1909—AUGUST, 1910

Calculations of the total plankton that passed Havana September, 1909—August, 1910, from the silk-net figures of that year, increased in

* This column gives per cent. in terms of dry matter.
† This column gives percentage on base of Illinois River channel, Chillicothe to Kampsville.

the average ratios found by Kofoid* to hold between silk-net and filter-paper volumes in 1896—1899, show a figure for the twelve-month period (200,477 tons) almost exactly treble the amount (67,750 tons) that was carried in the average year just prior to 1900. Of the twelve months' total about 89 per cent. (179,916 tons) was accounted for during the four months of the spring season, March to June inclusive, during which period 1,474 tons passed every twenty-four hours. The 14,025 tons that passed during the five months July to November inclusive, made up only 6.9 per cent. of the total for the year, but this amounted to ninety-one tons every twenty-four hours, and was enough if all settled to the bottom to supply 1,698 pounds per acre for every acre in the river below Copperas Creek dam at the average gage of that season and year (7.8 ft., Havana). The December—February plankton (6,536 tons) was less than half that of July—November, and only 3.2 per cent. of the total. The full twelve months' total, over 400,000,000 pounds, amounted to 24,279 pounds per acre for each acre of the approximate acreage in the river below Copperas Creek dam at recent under-bank-full stages (8 ft., Havana); or to nearly a hundred times the wet weight of the total bottom-fauna stocks of July—October, 1915, shells deducted, between Copperas Creek and Grafton (4,277,351 pounds). The dry weight of this plankton at two to five per cent. (8,000,000 to 20,000,000 pounds) was twenty to fifty times the estimated dry weight (at 10 per cent.) of the total bottom stocks of 1915 below Copperas Creek (427,735 pounds).

Complete figures for the plankton stocks produced in the full 120 miles between Havana and Grafton would doubtless also include, in addition to the Havana figures, new stocks of no small size added on the way down stream, both as a result of normal multiplication and lake and other backwater contribution. I do not take the fact that all of our down-stream plankton series between 1899 and 1910 showed a large decrease in volumes southward of Havana as ruling out the inference of continued though hidden increase, at a rate merely slower than the rate of decrease due to consumption and settling. The average time of passage between Havana and Grafton was 6.7 days at the average gage of July—November, 1909 (7.81 ft., Havana), and was 4.82 days at the average gage of March—June (Havana, 12.04 ft.). During upward pulses, rates of increase in plankton volumes (c.c. per m^3) were several times recorded both by Kofoid and the writer for the river channel at Havana and for Thompson Lake, both in spring and autumn months, 1896—1910, that amounted to over 25 per cent. in one day; while in extreme cases the increases ran to 60 to 70 per cent. in a single day, or 400 to 500 per cent. in a week.

* Bul. Ill. State Lab. Nat. Hist., Vol. VI., Art. II., 1903, pp. 552-554.

TOTAL PLANKTON PASSING HAVANA, SEPTEMBER, 1909—AUGUST, 1910

Season	Silk plankton c.c. per m.³	Ratio total plankton to silk plankton	Total plankton c.c. per m.³	Gage Havana average	Discharge Havana approx. av. ft. per second	Discharge Havana m.³ per 24 hours	Plankton passing per 24 hours	Plankton whole period	Per cent. of total	Equivalent lbs. per acre, 16,514 acres (river) below Copperas Creek dam. Gage, 8 ft., Havana
December—Feb. 90 days	0.20	6.87:1	1.37	11.96	20,000	48,090,240				
						Grams..	...65,883,628			
						Pounds.	145,246	13,072,140	...3.2	791
						Tons...	72	6,536		
March—June 122 days	13.98	1.99:1	27.82	12.04	20,000	48,090,240				
						Grams..	1,337,870,476			
						Pounds.	...2,949,449	359,832,778	..89.7	21,789
						Tons...	1,474	179,916		
July—Nov. 153 days	0.87	3.95:1	3.43	7.81	10,000	24,045,120				
						Grams..	..83,160,761			
						Pounds.	183,387	28,050,561	...6.9	1,698
						Tons...	91	14,025		

Year total (pounds) = 400,955,479; per acre (16,514 a.) = 24,279 pounds.
Year total (tons) = 200,477.

2. Stocks of Total Nitrogen and Nitrates in the River Channel at Chillicothe, 1914—1915

Comparison of the plankton figures obtained at Havana September, 1909—August, 1910, with the total nitrogen and nitrate figures for Chillicothe, March, 1914—February, 1915, does not suggest that plankton production in the river between Havana and Peoria has been at all in danger of limitation by the nitrogen supply at any season during recent years. The total nitrogen that passed Chillicothe in the twelve months (67,722 tons) was sufficient, if all metabolized without loss, to produce more than ninety times the actual stocks of plankton that passed Havana in the year 1909—1910 (based on a dry-matter per cent. = 5; nitrogen per cent. in dry matter = 7); while the stock of unused nitrogen in the form of nitrates (22,345 tons) was capable of producing under the same conditions more than twenty times the total plankton that actually passed Havana in 1909—1910. At the dry matter and nitrogen ratios assumed, only about 1,431,983 pounds out of the total of 35,444,859 pounds of nitrogen that passed Chillicothe in the year 1914—1915 would be accounted for as nitrogen in the form of living matter in 400,000,000 pounds of plankton (the approximate amount that passed Havana September, 1909—August, 1910).

If we could distribute the total nitrogen that passed Chillicothe over a river acreage of 26,782 acres (the estimated acreage below Chillicothe at about 8 ft., Havana, the average gage of July—November, 1910—1914), we would have 2,442 pounds per acre in the March—June period; 1,495 pounds per acre July—November; 1,119 pounds per acre December—February; and a total of 5,057 pounds per acre for the year. The nitrates, similarly distributed with correspondingly lesser poundages for the separate seasons, would amount to 1,668 pounds per acre for the twelve months on the same acreage.

The Peoria discharge data entering into the various tables following are the rating-table figures of Jacob A. Harman, as published in the special Report of the Illinois State Board of Health on Sanitary Investigations of the Illinois River, 1901, and more recently used by Alvord and Burdick in the Report of the Rivers and Lakes Commission on the Illinois River and its Bottom-lands, 1915. These figures are considerably higher than recent figures of the U. S. Geological Survey, which we did not have at hand, except in fragmentary form, when the manuscript for the present article was being prepared.

TOTAL NITROGEN PASSING CHILLICOTHE, 1914—1915

Season	Gage Peoria (av.)	Discharge Peoria* cu. ft. per second (av.)	Discharge Peoria cu. ft. per 24 hours	Total nitrogen p. p. m. (av.)	Total nitrogen pounds per cu. ft.	Total nitrogen pounds per 24 hrs.	Total nitrogen tons per 24 hours	
December—February, 1914—1915, 90 days	11.5	17,600	1,520,640,000	3.51	.000219	330,020	166	
Pounds, whole period, (90 days)								29,971,800
Pounds per acre (river, including Peoria Lake, below Chillicothe†), 8 ft., Havana								1,119
March—June, 1914, 122 days	13.0	22,900	1,978,560,000	4.34	.000271	536,189	268	
Pounds whole period (122 days)								65,415,058
Pounds per acre (river, including Peoria Lake, below Chillicothe), 8 ft., Havana								2,442
July—November, 1914, 153 days	9.5	11,700	1,010,880,000	4.15	.000259	261,817	130	
Pounds whole period (153 days)								40,058,001
Pounds per acre (river, including Peoria Lake, below Chillicothe), 8 ft., Havana								1,495
Year total (pounds)								135,444,859
Per acre, (26,782 a.)—pounds								5,057

* Nearest stream-measurement station with full data.
† Approximately 26,782 acres, gage, 8 ft., Havana.

Season	Gage Peoria (av.)	Discharge Peoria cu. ft. per second (av.)	Discharge Peoria cu. ft. per 24 hours	Nitrogen as nitrates p. p. m. (av.)	Nitrogen as nitrates pounds per cu. ft.	Nitrogen as nitrates pounds per 24 hours	Nitrogen as nitrates tons per 24 hours	
December—February 90 days	11.5	17,600	1,520,640,000	1.05	.000065	98,841	49	
			Pounds whole period (90 days).....					8,895,690
			Pounds per acre, (26,782 a.)*.....					332
March—June 122 days	13.0	22,900	1,978,560,000	1.71	.000106	209,727	104	
			Pounds, whole period (122 days).....					25,586,694
			Pounds per acre, (26,782 a.).....					955
July—November 153 days	9.5	11,700	1,010,880,000	1.06	.000066	66,718	33	
			Pounds whole period (153 days)....					10,207,854
			Pounds per acre, (26,782 a.).....					381
Year total (pounds).....								44,690,238
Per acre, (26,782 a.)—pounds.....								1,668

* River including Peoria Lake, below Chillicothe, 8 ft., Havana.

TOTAL NITROGEN, TOTAL PLANKTON, AND NITRATES PASSING ILLINOIS RIVER POINTS, 1909—1915

Season	Total nitrogen passing Chillicothe 1914—1915	Equivalent in plankton at ratio 1:280	Equals times actual plankton 1909—1910	Total plankton passing Havana 1909—1910	Nitrogen in plankton at ratio 1:280	Nitrates Chillicothe 1914—1915
December—February, 90 days	29,971,800 lbs. 14,985 tons	8,392,104,000 lbs.	× 641	13,072,140 lbs.	46,686 lbs.	8,895,690 lbs. 4,447 tons
March—June, 122 days	65,415,058 lbs. 32,708 tons	18,316,216,240 lbs.	× 59	359,832,778 lbs.	1,285,117 lbs.	25,586,694 lbs. 12,793 tons
July—November, 153 days	40,050,001 lbs. 20,000 tons	11,216,240,280 lbs.	× 399	28,050,561 lbs.	100,160 lbs.	10,207,854 lbs. 5,103 tons
Year	135,444,859 lbs. 67,722 tons	37,924,560,520 lbs.	× 94	400,955,479 lbs.	1,431,983 lbs.	44,690,238 lbs. 22,345 tons

3. Total Stocks of Oxidizable Matter in the River at Chillicothe, 1914—1915

Not only the plankton, but in addition all the other oxidizable matter carried in the stream-flow, whether suspended or dissolved, may be regarded as potential detritus or as potential microorganisms, some portion of which, in some form or other, may be useful as food to the bottom animals or to the organisms on which they themselves feed somewhere in the course of the stream below the sampling point. If the total oxidizable matter at Chillicothe 1909—1914 was in about the same ratio to the total nitrogen as in 1900—1902 (about ten times total nitrogen in the winter and spring months, and seven to nine times the nitrogen figures in midsummer and autumn), we would have had passing Chillicothe in the entire year, March, 1914, to February 1915 a total of 617,137 tons, or over 1,200,000,000 pounds total oxidizable matter, dry weight, or some sixty to a hundred and fifty times the total dry weight of the plankton that passed Havana in the twelve months September, 1909, to August, 1910 (eight million to twenty million pounds). If this enormous total load could be settled out and apportioned equally to the approximate 26,780 acres of river between Chillicothe and Grafton at gage 8 ft., Havana, each acre would receive in the course of the year 46,086 pounds, an average equal to more than seventeen hundred times the average dry weight poundage (about 10 per cent.) of bottom animals per acre (twenty-six pounds) found in the summer of 1915 between Chillicothe and the river's mouth. The employment of vertical instead of surface chemical samples for the determination of loss on ignition would with little question, also, show still higher values of total oxidizable matter than those here figured, particularly in seasons of recession from flood, when the dead suspended organic matter increases heavily in concentration from the surface downward. (See table on p. 456.)

4. The Portion of the Plankton Settled out or Consumed

Basing the computations on percentage decreases in silk-plankton volumes (c.c. per m.^{3}) between Havana and Grafton in June and August 1910, and on rates of increase in discharge between Havana and the mouth of the river in the spring and midsummer months, but taking no account of normal multiplication, there is found for the nine-months growing season, March—November, 1909—1910, a total loss of plankton in the 120 miles below Havana of 243,503,139 lbs., or almost exactly two thirds of the total stocks that passed Havana during the period (387,883,000 lbs.). The dry weight of this lost plankton at 5% (12,175,156 lbs.) amounts to nearly 30 times the dry weight, estimated at 10%, of the bottom animals found in 1915 in approximately the same reach of river in which the loss occurred (total bottom-fauna stocks Copperas dam—Grafton, 1915, 4,277,350 lbs; dry weight at 10%, 427,735 lbs.).

Estimate of Total Oxidizable Matter Passing Chillicothe 1914—1915. (Dry Weight)

Season	Total nitrogen pounds	Factor for total oxidizable*	Total oxidizable matter pounds (dry)	Total oxidizable matter tons (dry)	Total oxidizable matter, lbs. per acre 26,782 acres below Chillicothe 8 ft., Havana
December—February	29,971,800	× 10	299,718,000	....	11,191
March—June	65,415,058	× 10	654,150,580	....	24,424
July—November	40,058,000	× 7	280,406,007	....	10,469
12 months	135,444,859	....	1,234,274,587	617,137	46,084

* Loss on ignition not determined in sanitary chemical samples of 1914—1915. Here estimated on basis of ratios holding in 1900—1902 at Averyville between total nitrogen and total loss on ignition.

That the greater part of the plankton lost, or all of it, was settled out or consumed by larger organisms, rather than that it perished because of any failure of the food supply (particularly nitrogen), is forcibly suggested by two or three considerations: that the losses took place at the greatest rate during the hot season, when the current was least and settling easiest, the rate of loss in August 1910 being 98%; and that instead of there appearing any evidence that the losses were due to diminution in food, both the total limnetic nitrogen and the nitrogen in the form of nitrates increased down-stream both in the spring and midsummer—autumn months in 1914, the nearest year for which we have nitrogen figures. I note here that incomplete studies on the succession of Algae, Protozoa, Rotifera, and Entomostraca in some of our down-stream series of plankton-catches suggest that a good part of the loss in plankton below Havana in the spring months during rising pulses of Entomostraca may be due to internal consumption, within the plankton population itself. In May, 1899, in fact, these four groups of micro-organisms showed a progression in reaching their maximum abundance, each at a station farther down stream. In the circumstances the presumption seems strong that each pound of Cyclopidae or Rotifera taken near the mouth of the river represents several pounds of smaller plankton species eaten farther up stream. (See tables, pp. 458, 459.)

5. Coincidence of Richer and Poorer Plankton and Bottom-Fauna Reaches in the River below Chillicothe

The fact that there are shown, on a basis of the plankton and bottom-fauna figures (1899—1915), such close coincidences between the location and extent of the richer and poorer plankton and bottom-fauna reaches between Chillicothe and the mouth of the river is not, I think, to be taken too quickly as in itself dependable evidence that the bottom fauna is to any certain and large extent a simple function of the volume or weight of plankton above it. Not only, however, does it appear that both in its bottom fauna and its plankton stocks the sixty odd miles of low-sloped river channel between Chillicothe and Havana is far richer on the average than the lower river reaches, but the decrease down stream, on a broad scale, is in each case found to be progressive, and in fact in substantially similar ratios, if the comparison is made with the midsummer plankton figures. (Table, page 460.) The finding, on the contrary, in August 1913, in a local section of low-sloped channel in the lower river, of a rich plankton-consuming population of Sphaeriidae that was apparently not far from as rich as the best found in 1915 in the middle Illinois Valley district suggests that the very general lack of a suitable substratum for small Mollusca in the channel of the Illinois below Lagrange may have more to do with the decrease of the bottom fauna in the lower river than the decrease in the stock of plankton above it. Other influences that may have some bearing on the average very poor showing made by the bottom fauna in the lower river in 1915 will be taken up farther on.

LOSS OF PLANKTON BETWEEN HAVANA AND GRAFTON, 1909—1910

Season	Total plankton passing Havana pounds	Loss, %, (in c.c. per m^3) Havana to Grafton 1910*	Approx. incr. in discharge Havana to Six Mile Island 1903	Total plankton passing Grafton pounds	Loss of plankton Havana to Grafton pounds	Loss of plankton Havana to Grafton per cent. by weight
March—June 122 days	359,832,778	80%	100%	143,530,438†	216,302,340	61%
July—November 153 days	28,050,561	98%	50%	849,762	27,200,799	97%
Nine months	387,883,339				243,503,139	62%

* Basis June, 1910, for March—June; Aug. 1910, for July—November.
† Calculation made in same manner as in table on page 450.

TOTAL NITROGEN PASSING ILLINOIS RIVER POINTS, 1914. (COMPARISONS ARE WITH CHILLICOTHE.)

	March—June, 122 days			July—November, 153 days		
	Parts per 1,000,000	Average discharge ft. per sec.	Total pounds nitrogen 122 days	Parts per 1,000,000	Average discharge ft. per sec.	Total pounds nitrogen 153 days
Chillicothe	4.34	22,900 (Peoria)	65,415,058	4.15	11,700 (Peoria)	40,058,001
Havana	3.65	Small increase	Small decrease	2.95	Small increase	Decrease
Grafton	4.02	More than doubled	Great increase	2.73	Increase 50% +	Increase*

* Per cent. increase in discharge greater than decrease in p. p. m.

NITRATES PASSING ILLINOIS RIVER POINTS, 1914. (COMPARISONS ARE WITH CHILLICOTHE.)

	March—June 122 days			July—November, 153 days		
	Parts per 1,000,000	Average discharge ft. per sec.	Total pounds nitrogen as nitrates 122 days	Parts per 1,000,000	Average discharge ft. per sec.	Total pounds nitrogen as nitrates 153 days
Chillicothe	1.71	22,900 (Peoria)	25,586,694	1.06	11,700 (Peoria)	10,207,854
Havana	1.93	Increase	Increase	1.06	Increase	Increase
Grafton	2.12	More than doubled	More than doubled	1.46	Increase 50% +	More than doubled

PLANKTON VOLUMES, BOTTOM FAUNA, AND BOTTOM NITROGEN, 3 MAIN REACHES, CHILLICOTHE—GRAFTON

Reach	Plankton volumes, % on base Reach I			Flood velocity	Bottom fauna, 1915		Nitrogen in mud, river channel (to depth 3 in.)	
	May, 1899 (Kofoid)	June, 1910 (Forbes & Richardson)	August, 1910 (Forbes & Richardson)	18 ft. Peoria % basis	All-zone average pounds per acre	Per cent. on base of Reach I	Pounds per acre	Per cent. on base of Reach I
I Chillicothe—Havana 60.5 mi.	100 *6**	100 *10*	100 *7*	100	555	100	1918	100
II Havana—Lagrange 42.5 mi.	44 *4*	38 *3*	8 *3*	150 ca.	88	15	1417†	*73*
III Lagrange—Grafton 77.5 mi.	7 *6*	12 *3*	3 *3*	200 ca.	10.4	2		

* The Italic figures give the number of collections.
† Where there *is* mud.

6. The Plankton of Thompson Lake, 1909—1910

As shown by volumes per cubic meter of silk plankton, based on vertical samples, the middle of Thompson Lake and the river channel at Havana averaged nearly the same in plankton content during the four months March—June, 1910 (Thompson, 12.77 c.c.; river, 13.98 c.c.); while in the July—November period of five months Thompson Lake (5.21 c.c.) averaged about six times as rich as the river (0.87 c.c.). Expressed in terms of pounds per acre to a depth of one meter, these volumes of plankton amount to around 114 lbs. for the lake and 124 lbs. for the river in the March—June period, and to 46 lbs. for the lake and 8 lbs. for the river in July—November. If these quantities of silk plankton are multiplied, both in the case of the river and the lake, by the Kofoid silk-filter-paper ratios for river samples, 1897—1899, the poundages for March—June would be about twice those just given, and for July—November about four times those figures. On the other hand, if depth is taken into account, and total amounts of plankton standing over an acre in the river and the lake to the full average depth at the collecting station are figured, the river acre in March—June will be found to have more plankton standing over it at a given time than an equal area in the central portion of Thompson Lake; and in July—November, about half as much, instead of only one sixth as much, as an acre in the lake.

Plankton Thompson Lake and Illinois River, Havana, 9 months. March—November, 1909—1910

	Gage, Havana average	Depth coll. sta. feet, av.	Depth coll. sta. meters, av.	Silk plankton c.c. per m^3	Silk plankton lbs. per acre to depth 1 meter
March—June incl.					
Thompson L.	12.04	12.23	3.7	12.79	114
Illinois River	12.04	22.23	6.7	13.98	124
July—November incl.					
Thompson L.	7.81	8.00	2.4	5.21	46
Illinois River	7.81	18.00	5.4	0.87	8

General Comparison of the Illinois River and its Connecting Lakes in the Food Resources of a Fishery and in Fish Output

Bottom and Limnetic Nitrogen, Plankton, etc.

In the fact that the Illinois Valley lakes, only in a lesser degree than the river itself, are in the spring or later flood-seasons of all but very exceptional years open to receive the sewage-laden water from the upper Illinois River and the Chicago Sanitary Canal, they differ materially from the isolated glacial type of lake and from ponds or other waters which are closed throughout the year to outside sources of nutriment. Such supplies as the river lakes receive, they are able to retain in great measure when their outflow is reduced to little or nothing by the falling of the water levels, but the acquired resources of the river are continually drained away by the current, these losses being especially heavy when the bottom sediments are being stirred up and scoured out in times of flood. Hence the river, as we have seen, is not able to accumulate and hold, even in the reach of extremely low-slope between Copperas Creek dam and Lagrange, surplus stocks of these substances and the residues from their decay as large as the stocks found in the lakes, whether in their deeper open, or in their weedy littoral portions; while in the relatively swifter channel below the Lagrange dam the difference is still further emphasized. So far as the plankton alone is concerned, the surplus stocks on hand at a given time per cubic meter of water in Thompson Lake in 1909—1910 exceeded those in the richest part of the river at Havana, opposite, at whatever season, with the percentage of difference in favor of the lake largest during the more critical season of low productivity, July—November.

That the central Illinois Valley lakes are also to a considerable extent their own furnishers, through the growth and decay of shore vegetation, of their permanent stocks or organic food-materials, is suggested by the size of the annual crops or aquatic vegetation, some of which is rooted, in their shallower zones; as well as by the fact that the stocks of nitrogen, organic carbon and other oxidizable substances in the upper layer of bottom soil are appreciably larger in the weedy littoral than in the deeper open water. The river, whether in the Havana district or above or below, has as offset extremely little weedy shore, where rich stocks of similar kind can originate and decay, or where permanent lodgment can be furnished for settling suspended organic matters carried in from points up stream.

Bottom and Shore Fauna

In the case both of the plankton and of the various other food substances directly or indirectly usable as food by the bottom and shore animals, our data, as far as they go, point clearly to the presence at all

times, both in the river and in the lakes, of surplus stocks of a size far more than sufficient to supply the immediate needs even of vastly richer bottom and shore populations than we found in 1914—1915. But though the river, at least in the region of low slope between Chillicothe and Havana, could thus theoretically produce as large poundages of bottom and shore fauna as the lakes, or even larger, the figures for stocks on hand in the two years mentioned, as well as other evidence, tend rather to prove that the lakes are over their average acreage the better producers, and that their richest fauna is developed in the weedy littoral, where also occur the largest deposits of nitrogen, organic carbon, and other oxidizable matters.

As the margin between the bottom and shore fauna stocks on hand in 1914—1915, even in the most productive lake and river areas, and the food requirements, in kind, of a normal fish population, as of 1908 and neighboring years, seems clearly to be very much smaller than that between the supplies and the needs of the bottom and shore fauna itself, it may be supposed that *figures for stocks on hand* after four or five months' feeding by fishes can not be accepted as they stand, quite as confidently as plankton and nitrogen figures for use as an index of actual total productivity. If this is the case, and if it is also true, as we have reason to think, that the lakes rather than the river are not only the favorite feeding-grounds of the greater part of the large bottom-feeding fishes during the 9-months growing season but also the largest producers of fish flesh, then we should expect that complete figures for *total annual yield* of bottom and shore invertebrates for the river and lake acreage in the Havana district would show a yet greater difference in favor of the lakes than is shown by the figures of stocks on hand as of July—October, 1914—1915. A further point in favor of the lakes is the fact that the very heavy bottom-fauna poundages of the river channel just above Havana consist largely of heavy-shelled snails, which we can not believe are easily made use of as food by any but the largest bottom-feeding fishes. Looked at in this way, the richest river valuations may represent accumulation in the presence of light feeding; while the lower poundages of bottom animals in the lakes opposite may be looked upon as residues from originally much larger stocks, fed down to a closer point than the river stocks, in consequence both of a relatively greater size-availability and of their location within the main-feeding range.

Fish Yields

On a plain acreage basis the total river acreage, at a gage of 10 feet, Beardstown*, between La Salle and Grafton, with equal productivity assumed in both river and lakes, should in 1908† have supplied around 18% of the total fish yield of that year, and the lakes about 82%. In

* Gage selected by Alvord and Burdick as that prevailing on an average one half of the year, 1900—1913.

† Last year for which we have full figures for fish yields.

the same year the river between Copperas Creek dam and Lagrange dam, where the lake acreage is largest relatively to the total, should have furnished about 10% of the total fish yield; the river between La Salle and Copperas Creek dam, about 17%; and the river below Lagrange, about 37%. That the river and lake yields of fish per acre are not equal, however, is suggested with considerable force by more than one consideration. The first of these is the fact that in all the recent years for which we have records the largest poundages of fish per acre have been taken in the reaches with the largest quotas of connecting lake-acreage. Taking the year 1908 as an illustration, and using the figures for separate shipping points obtained by the Illinois Fish Commission in that year, we find for the 59.3 miles of river and lakes between Copperas Creek dam and Lagrange dam, with about 90% of its acreage consisting of lakes and ponds, an average fish-yield per acre for water levels prevailing half the year, of 178.4 pounds; for the 87 miles from La Salle to Copperas Creek dam, with about 83% lakes, 130.4 pounds; and for the lower 77 miles, Lagrange to Grafton, with around 63% lakes, only 69.8 pounds.

If, again, we seek to reach conclusions concerning fish yields for the central Illinois Valley district from the bottom- and shore-fauna data of 1914—1915 we can only suppose that the average yield of the river per acre in recent years between the Copperas Creek and Lagrange dams (with 705 lbs. bottom fauna average) has amounted to less than half the average yield of the lakes opposite (with 1,447 + lbs. bottom- and weed-fauna average). Or, to put it another way, while the river's quota of the total fish catch in this reach on a plain acreage basis in 1908 was 10%, its capacity on a basis of the bottom- and shore-fauna figures of 1914—1915 uncorrected, stands at about 5% of the total.

That both the river and the lake yields of fish per acre have been lower in recent years in the reach above Copperas Creek dam and in the reach below Lagrange than in the district between, is suggested both by our bottom-fauna data from the river and by such incomplete figures as we have from Peoria Lake and Meredosia Bay (1913 and 1914), and also by the fact that the differences in fish yield per acre in 1908 between those two reaches and the Havana section are much greater than the difference in the ratios of lake to total acreage. That, however, the per cent. decrease in fish-yield in the lakes in these two reaches is less than the decrease in the river may perhaps be accepted as circumstantially proven by the greater decrease in the river bottom-fauna figures than in the figures of fish yield themselves.

FISH YIELD, PER CENT. LAKE ACREAGE, AND BOTTOM AND SHORE FAUNA

Reach	Fish catch 1908 lbs. per acre* Ill. Fish Commission	Per cent. lake acreage to total, 1908	Bottom-shore fauna lbs. per acre river, 1915	Bottom-shore fauna lbs. per acre lakes, 1914—1915
La Salle—Copperas Creek dam 87.1 miles	130.4 *73*†	82.9 *91*	264 *37*	Incomplete data
Copperas Cr. dam—Lagrange dam 59.3 miles	178.4 *100*	90.4 *100*	705 *100*	1447 *100*
Lagrange dam—Grafton 77.5 miles	69.8 *39*	62.9‡ *69*	10.4 *1.+*	Incomplete data

* For estimated acreage used see next table.

† Italic figures are Roman figures reduced to per cent.'s on base of middle reach as 100.

‡ This percentage greatly reduced between 1908 and 1915; the others in lesser degree.

River and Lake Acreage (approximate), 1908 at Gage 10 ft. Beardstown, and Fish Catch

Reach	River 1908 acres	Lakes 1908 acres	Total acreage 1908 acres	Per cent. lakes	Per cent. river	Fish catch 1908 lbs. total	Fish catch 1908 lbs. per acre
La Salle—Copperas Creek dam 87.1 mi.	8,200*	39,500†	47,700	82.8	17.2	6,222,000	130.4
Copperas Cr. dam—Lagrange dam 59.3 mi.	5,900	56,000	61,900	90.4	9.6	11,050,000	178.4
Lagrange dam—Grafton 77.5 mi.	10,600	18,000	28,600	62.9	37.1	1,998,000	69.8
La Salle—Grafton 223.9 mi.	24,700	113,500	138,200	82.1	17.9	19,270,000	139.7

* Wide waters of Peoria Lake deducted, giving the river the average number of acres per mile for Henry—Chillicothe and Peoria—Copperas Creek dam.
† Includes wide waters of Peoria Lake.

FISH CATCH, ILLINOIS RIVER AND LAKES, 1908
(ILL. FISH COMM.)

La Salle to Copperas Creek dam		
La Salle to Hennepin	520,000 lbs.	
Henry to Lacon	852,000 "	
Chillicothe	350,000 "	
Peoria	2,800,000 "	
*Pekin (one half)	1,700,000 "	
Total	.....	6,222,000 lbs.
Copperas Cr. dam to Lagrange dam		
*Pekin (one half)	1,700,000 lbs.	
Havana	3,800,000 "	
Bath	1,900,000 "	
Browning	1,700,000 "	
Beardstown	1,950,000 "	
Total	.....	11,050,000 lbs.
Lagrange dam to Grafton		
Meredosia	684,000 lbs.	
Naples to Pearl	409,000 "	
Kampsville to Grafton	905,000 "	
Total	.....	1,998,000 lbs.
Grand total	.....	19,270,000 lbs.

* Pekin catch divided between adjacent reaches because of heavy fishing by Pekin crews in Spring Lake.

BOTTOM- AND SHORE-FAUNA VALUATIONS, 1915, IN TERMS OF MONTHS' SUPPLY FOR ANNUAL INCREMENT IN FISH-WEIGHT OF 150 POUNDS PER ACRE

How close to a critical minimum, from the point of view of the fishery, the stocks of bottom invertebrates in the lower Illinois River had dropped in July—October, 1915, after 5 to 8 months' feeding, is most clearly seen after we have changed the bottom-fauna valuations into terms of months' supply of food for an annual yield of fish somewhat nearly equal to the average for the year 1908 on the acreage estimated to prevail during half of the year. In the tables next following, these calculations are shown as they come out for an annual weight increment of 150 lbs. per acre, the year's feeding being completed in 9 months (March—November), animal food only being used, and an average consumption of five pounds of bottom and shore invertebrates (shells of mollusks deducted) for one pound increase in fish weight being assumed. The feeding ratio (5:1) adopted is the estimate of Walter* for carp and carp-like fishes, living on wild animal food, and is close to the

* Die Fischerei als Nebenbetrieb des Landwirtes u. Forstmannes. 1903.

ratios estimated by Otterstrom* and Kronheim† for trout fed on raw fish or "mostly animal food". The rate of consumption of bottom (or shore) invertebrates per month for the nine-months "year" works out at about 83 pounds:

$$\frac{150 \times 5}{9} = 83.3$$

Expressing the bottom- and shore-fauna valuations of 1915 in multiples of the average monthly consumption rate, we find that in July—October of that year there were 120 miles of the Illinois River below Havana whose average supplies of free-living bottom-invertebrates were sufficient to last at such a rate only 30 days or less beyond the date of collection; and 77.5 miles below Lagrange dam in which there were sufficient stocks to last only 3 days. The much richer stocks in the river above Havana, in spite of the exceedingly low valuations in the lower river, were sufficient to bring up the average supply for the entire 180.5 miles between Chillicothe and Grafton to a figure of 3.1 months—which was also the average for the 60.5 miles between Chillicothe and Copperas Creek dam. In the reach of 59.3 miles between Copperas Creek and Lagrange, where an average supply sufficient for 8.5 months was found, there was a short stretch of 16.8 miles (immediately above Havana) where the stocks were sufficient to last for over 30 months, but a relatively much greater part of the bottom fauna in this locally very rich section was made up of large heavy-shelled Mollusca than was the case in any other part of the river.

In contrast with all of these river figures except those for the 16.8-mile reach between Copperas Creek and Havana, the average stock of twelve lakes between Copperas Creek and Lagrange in July—October, 1914—1915, included a three months' supply of *bottom fauna only* for the whole acreage, a minimum‡ of 25.5 months' supply of shore animals living above the bottom in the weedy acreage within the 4-foot line, and a combined average supply of bottom- and shore-animals sufficient for 17.4 months. (See table, p. 469.)

Supplies of bottom animals that were well above the average of *all* the lakes studied, were shown by the Class I and Class II lakes (of the type of Thompson and Quiver respectively): average of five deeper bottom-land lakes, 4.2 months; average of two deep, sand-beach lakes, 10.2 months. Thompson Lake in 1914 had in August to October a 6.5 months' supply of bottom invertebrates over its entire acreage, and a 25.7 months' supply of weed animals in the 1—4-foot zones—or a combined average supply, on a rough acreage basis, sufficient for 20.8 months. The low rating of bottom-fauna stocks in the very shallow weedy lakes, such as Flag, Duck, Dennis, (0.6 to 1.1 months' supply),

* Fiskerei beretning, 1911, pp. 244—254.
† Bibl. der Gesamten Landwirtschaft, Bd. 34, 1907.
‡ "Weed fauna" catches cover the upper 9 inches only.

was of little importance by comparison with the very high weed-fauna figures from these lakes, the combined bottom and weed fauna averages (if Crane Lake be excepted) apparently including a supply sufficient for not less than 25 to 30 months. (See table, p. 470.)

Bottom and Shore Fauna as Food for Fishery

1. Illinois River, July—October, 1915

Italic figures=months' supply, at 83 lbs. per month, for 9 months' growing season for fish-weight-increment of 150 lbs. per acre, feeding ratio 5:1.

	Miles	Bottom fauna all-zone av. lbs. per acre	Months' supply remaining on date of collection*
Chillicothe—Copperas Cr. dam	43.7	264	*3.1*
Copperas Cr. dam—Lagrange	59.3	705	*8.5*
Copperas Cr. dam—Havana	16.8	2,693	*32.4*
Havana—Lagrange	42.5	83	*1.0*
Lagrange—Grafton	77.5	10.4	*0.1*
Chillicothe—Grafton	180.5	261	*3.1*

Hypothetical Fish-Yields for the River and Lake Acreage between Copperas Creek Dam and Lagrange, on Basis of Bottom- and Shore-Fauna Stocks of July—October, 1914—1915

In the table on page 471 are shown figures representing the potential value in fish, at the Walter ratio (5:1), of the bottom- and shore-fauna stocks remaining unconsumed in the central rich district between Copperas Creek dam and Lagrange July—October, 1914—1915, after 5 to 8 months of feeding. The total hypothetical yield of the unconsumed stocks of food thus figured (16,103,580 lbs. of fish, from 80,517,900 lbs. bottom and shore animals), is greater by about 50% than the actual fish catch of 1908 (a banner year) in the same district. Of this total, 831,900 lbs., or 141 lbs. per acre, accrues from about 6,000 acres of river, bearing over 4,000,000 lbs. of small bottom animals; and 15,271,680 lbs., or 289 lbs. per acre, from about 52,000 acres of lakes and other backwaters, bearing not less than 76,000,000 lbs. of small bottom- and shore-animals, of which over 60,000,000 lbs. comes from the upper levels in the shallower, more densely weeded acreage.

* Dates of collection, July—October (after 5 to 8 months' feeding).

BOTTOM AND SHORE FAUNA AS FOOD FOR FISHERY

2. LAKES, COPPERAS CREEK DAM—LAGRANGE, JULY—OCTOBER, 1914—1915

	Bottom fauna		Weed fauna		Combined average	
	Lbs. per acre	Months' supply left on date collection	Lbs. per acre	Months' supply left on date collection	Lbs. per acre	Months' supply left on date collection
I						
Five deep bottom-land lakes, 1914—1915	352	*4.2**				
Thompson, L., 1914	542	*6.5*	2,135	*25.7*	1,732†	*20.8*
II						
Two sand beach lakes, 1914—1915	848	*10.2*				
Quiver L., 1914	1,521	*18.3*				
III						
Three shallow weedy lakes	57	*0.6*	2,125	*25.6*	2,182‡	*26.2*
IV						
Two very shallow weedy lakes	94	*1.1*	2,508	*30.2*	2,602‡	*31.3*
Average twelve lakes, all classes	255	*3.0*	2,118	*25.5*	1,447†	*17.4*

* For explanation of Italic figures see under heading of previous table.
† Equals acreage-weighted average.
‡ Equals sum of bottom and weed fauna averages (all acreage weedy).

BOTTOM- AND WEED- FAUNA STOCKS AND HYPOTHETICAL FISHERY VALUE, 1915, COPPERAS CR. DAM—LAGRANGE

	Approximate acreage 8 ft. Hav.	Bottom and weed fauna lbs. per acre			Total stocks bottom or weed animals	Hypothetical fish yield, lbs. at 5:1	
		Bottom	Weed	Bottom and weed		Total	Per acre
River all zones	5,900	705	...	...	4,159,500	831,900	141
Lakes, all zones (bottom fauna only)	52,760	255	...	...	13,453,800	2,690,760	51
Lakes, 0—4 ft. (weed fauna only)	29,700	...	2,118	...	62,904,600	12,580,920	423
All lake area (bottom and weed fauna)	52,760	...	...	1,447	76,358,400	15,271,680	289
Total acreage	61,900	...	...	1,300	80,517,900	16,103,580*	260*

* Comparing with 11,050,000 lbs. actual catch in this district in 1908, or 178 lbs. per acre.

The Reproductive Rate of the Bottom Animals

Petersen, writing of the bottom fauna of the Danish fishing grounds, 1911—1918, has expressed the opinion that the bottom animals at least reproduce themselves in weight each year. This conclusion was based by Petersen on the observed fact that from year to year, on the average, similar quantities of bottom animals are found over the same areas, along with similar populations of bottom-feeding fishes. It is perhaps true that more regularity in this respect might be expected in sea-bottom than in the bottom muds of our relatively shallow inland rivers and lakes, which are subject to extremes of temperature; to floods and consequent washing and filling; to disturbance by seining and artificial dredging for navigation channels; and to other unfavorable influences.

With more particular reference to growth rates in small bottom Mollusca, I note that Petersen (1911) remarks that a small Sphaerium-like form, Abra sp., reproduces its weight *several times* in a year; and that F. C. Baker recently observed of very young specimens of the genus Ampullaria, from Ceylon, that they doubled in size in an aquarium in 3 months.

Body weights taken by us of a series of 3 to 63-month specimens of one of the commonest snails from the Illinois River and its connecting lakes, *Vivipara contectoides,* all from late July collections, 1913—1914, indicate an average increase in body weight in one year running from 63 to 100% for the different age-groups studied.

GROWTH OF VIVIPARA CONTECTOIDES,* HAVANA

Age, months (estimated)	Years (estimated)	Maximum length of shell, mm.	Body weight† mg.	Increased weight next 12 months mg.	Per cent. increase next 12 months
3 ca.	0.25	11.5	160	132	82
12—15	1.00—	13.0	292	186	63
24—27	2.00—	15.0	478	438	91
36—39	3.00—	20.0	916	800	87
48—51	4.00—	27.5	1,716	1,734	101
60—63	5.00—	39.0	3,450		

The possibilities of multiplication of this particular snail, if left to itself, are even better shown by an analysis of a collection from Seebs

* All weights are of late July specimens, 1913; 3-months' specimens, evidently from spring brood same year; not possible to determine whether specimens one year and up were from spring or midsummer broods.

† Corrected for loss in alcohol.

Lake containing 100 specimens, ages 3 months and upwards, taken in late July, 1913. Out of 32 specimens over 32 months old, which were capable of 87 to 101% increase in body weight in the next 12 months, 30 carried advanced embryos (midsummer brood) totaling 460.

Figuring the average increase in body weight of young and adult age-groups in the next 12 months at 82.2%, the total body weight of the entire collection (without embryos), which was 72.286 grams at date of collection, would be approximately 131.7 grams one year later. Twelve months' growth in the 460 embryos, assuming that all lived, might be expected to amount in the average individual to at least 4/5 of the average body-weight of 12 to 15-month specimens (see table), or 233.6 mg. each, making the total weight-increment in the 460 embryos in 12 months 107.4 grams. Adding the increase in the embryos and that in the young and adults to the original total body-weight of the collection (72.3 grams) we have, 12 months after date of collection, without making any allowance for increase from a spring brood, a hypothetical total weight of 239.1 grams, or 3.3 times the weight with which we started.

POSSIBILITIES OF GROWTH OF VIVIPARA CONTECTOIDES
(BASED ON COLLECTION FROM SEEBS LAKE, JULY 25, 1913)

Age groups (estimated)	Av. rate increase in body-weight next 12 months	Advanced embryos (of midsummer brood)
32 specimens over 27 months	87—101%	460 (in 30 specimens)
6 specimens, 24—27 mos.	91%	
22 specimens, 12—15 mos.	63%	
40 specimens, 3—4 mos.	82%	
Total, 100 specimens	82.2%	460

Gross weight of collection, 94.0 grams.

Body weight (corrected for loss in alcohol)	72.3 grams
Increase in body-weight next 12 months, at 82.2%	59.4 "
Increase in weight of embryos, next 12 months, at 233.6 mg.* each	107.4 "
Total	239.1 grams

=3.3 × original weight.

* Equals 4/5 of weight of 12—15-mo. specimens (preceding table).

Changes in the Quantity of the Bottom-Fauna Stocks between 1913 and 1915

Various conditions or agencies besides any heretofore mentioned are doubtless capable of effecting local or temporary changes in the composition and weight of the bottom and shore animals either in the river or the lakes. Among those peculiar to the river may be mentioned the occasional scouring effect of floods in the regions of steepest slope, resultant natural filling at points farther down stream, and the cutting away of the river floor by artificial dredging for channel improvement. In the lakes in which the heaviest commercial fishing is carried on, injury may be done to the bottom animals in the fall of the year by the heavy tackle used. Either in the river or in the backwaters variations of importance in the size of the bottom-fauna stocks may doubtless result from changes in the size of the population of bottom-feeding fishes, these variations being in the direction either of decrease or accumulation. Mortality from other unknown causes no doubt occurs at times, as seemed to be the case with the larger snails in Quiver Lake between July 1914 and July 1915. Of water pollution I note that this was not anywhere an important cause of mortality in the river bottom-fauna below Chillicothe up to and including 1915.

Comparison of such data as we have for the season of 1913 with the more complete results obtained in 1915 indicates generally a quite satisfactory correspondence both in average composition and size of the bottom-fauna stocks in the longer reaches of river channel between Chillicothe and the Kampsville dam, both series of collections bringing out clearly the contrast between the more productive reaches of channel above Havana and the decidedly poorer stretches below. The most important single point of disagreement between the 1913 and 1915 river-figures concerns the finding in 1913 in the lower 30 miles, where in 1915 the average channel stocks of bottom animals were no larger than anywhere else in the lower 75 to 100 miles, of a rich local fauna of Sphaeriidae which apparently compared very well with the best found in the rich Havana district. The presence, only locally, of so rich a bottom population seems to imply the existence in that part of the river of an adequate food supply, and is doubtless sufficiently explained otherwise by its occurrence in a region of less than average slope and velocity and more favorable conditions for sedimentation than are found in most of the lower 100 or more miles of channel. For its disappearance between 1913 and 1915 no certain explanation offers. I note, however, that it is in this wider, and on the average swifter portion of the channel that bar formation is most frequent in the Illinois and that dredging operations for channel maintenance are oftenest carried on. It is also in this part of the river, where for more than 70 miles the far greater portion of the bottom-land lakes had been leveed and drained before 1915, that sudden depletion of sporadic bottom-animal populations might most

easily be accomplished by the waves of large carp and buffalo that advance up the river every spring, and that have in recent years been practically confined within the bank limits of the river itself for feeding range until they have reached a point near or above the Lagrange dam. The last hypothesis as an explanation of this single circumstance, and, as well, of the comparative poverty of the bottom fauna of the entire lower 77 miles of the river, receives some support from the fact that while in 1915 the bottom-fauna stocks between Lagrange and Grafton dropped nearly to the vanishing point, both in the channel and shore zones, between Lagrange and Havana, where there was still a large lake-acreage open to the river, the important decrease in the bottom fauna over Havana district figures was to be seen only in the channel valuations and was apparently, for the most part, explained by the character of the channel bottom.

Only two of the twelve lakes in the Havana district (Thompson and Quiver) were examined both in 1914 and 1915 with sufficient completeness to permit a fair comparison of their stocks of bottom animals as of these two years. While there was an increase of 60% in the average quantities (by weight) in the deeper open water of Thompson Lake from 1914 to 1915, the changes in the shallower zones, and in both the deeper and shallower areas in Quiver Lake, were in the direction of decrease,

BOTTOM-FAUNA STOCKS, ILLINOIS RIVER CHANNEL, 1913 AND 1915, (JULY—OCTOBER)

Reach	Average number individuals per collection.* 1913	Average number individuals per sq. yard 1915	Average pounds per acre 1915†
Chillicothe to Copperas Cr. dam	101 *10*‡	203 33	239
Copperas Creek dam to Havana	280 *6*	880 *16*	3,029
Havana to Lagrange	22 *8*	15 *16*	22
Lagrange to Kampsville	29 *15*	17 *9*	7
Kampsville to Grafton	§ *9*	28 *7*	6

* All hauls with ordinary iron dredge, with coarser mesh bag than in 1915.
† Not figured for 1913 because of less certain quantitative value of 1913-series of collections.
‡ The Italic figures give the number of collections.
§ Five hauls at the foot of Six Mile Island yielded an average of nearly 1,000 specimens of *Musculium transversum* per collection; other hauls, poor.

the percentages ranging from about 30 to 70%. In Quiver Lake the principal part of the decrease resulted from a heavy falling off in the small Mollusca, the unusual numbers of dead snails found everywhere in the lake in 1915 seeming to point to some exceptional mortality from unexplained causes.

BOTTOM FAUNA STOCKS, LAKES IN VICINITY OF HAVANA, 1914 AND 1915, (JULY—OCTOBER)

	Pounds per acre, 1914	Pounds per acre, 1915	Incr. or decr. per cent.	Notes
Thompson Lake over 6 ft.	310 *8**	496 *8*	+60%	No essential change in composition of fauna
1—6 ft., some vegetation	903 *10*	647 *7*	—28%	" " " "
1—6 ft., no vegetation	501 *12*	296 *7*	—40%	" " " "
Quiver Lake over 6 ft.	2,805 *15*	803 *3*	—71%	" " " "
1—6 ft., some vegetation	388 *17*	158 *14*	—59%	Great decrease in snails and increase in Chironomidae between 1914 and 1915

* The Italic figures give the number of collections.

DETAILED VALUATION TABLES

I. Bottom Fauna, Illinois River, 1915

1. Chillicothe to Foot of Peoria Lake

8 Channel Collections, July 26—27 and Aug. 19
Chillicothe to Opposite Mossville

	Number per square yard		Pounds per acre	
Campeloma subsolidum	17.3		51.9	
Lioplax subcarinatus	39.7		47.6	
		88.2		244.1
Vivipara contectoides	28.2		141.0	
Pleurocera sp.	3.0		3.6	
Amnicola emarginata	2.5		trace	
Ancylus sp.	0.7		trace	
Physa sp.	2.5		0.5	
		143.7		70.4
Pisidium sp.	1.5		trace	
Musculium transversum	135.3		67.5	
Young Unionidae	1.2		2.4	
Asellus sp.	0.2		trace	
Small Oligochaeta	8.1		0.2	
Leeches (small spp.)	14.3		2.4	
		26.6		3.1
Caddis larvae (small spp.)	0.2		trace	
Chironomid larvae (smaller spp.)	3.7		0.5	
Chironomid larvae (larger spp.)	0.1		trace	
Total	258.5		317.6	

16 Collections, 4- to 7-ft. Zone, July 26—27, Aug. 17—19, 1915
Chillicothe to Opposite Mossville

	Number per square yard		Pounds per acre	
Campeloma subsolidum	13.3		39.9	
Lioplax subcarinatus	7.1		8.4	
		30.8		97.4
Vivipara contectoides	9.7		48.5	
Pleurocera sp.	0.5		0.6	
Somatogyrus sp.	0.6		0.3	
Valvata spp.	4.3		0.2	
Sphaerium stamineum	0.3		0.2	
		200.3		86.7
Musculium transversum	166.0		83.0	
Musculium jayanum	3.7		2.0	
Pisidium species	25.4		1.0	
Oligochaeta (small spp.)	21.0		0.7	
Leeches (small spp.)	17.6		2.9	
Asellus sp.	0.9		trace	
Hyalella knickerbockeri	7.5		0.3	
		68.7		13.3
Chironomid larvae (small)	9.9		1.3	
Chironomid larvae (large)	5.3		6.6	
Hexagenia, etc. (nymphs)	0.6		0.5	
Caddis-fly larvae (small)	5.3		0.7	
Agrionid nymphs	0.6		0.3	
Total	299.8		197.4	

9 Collections, 1- to 3-ft. Zone, July 26 and 27, 1915
Chillicothe to Opposite Mossville

	Number per square yard		Pounds per acre	
Lioplax subcarinatus	2.2		2.6	
		7.7		30.1
Vivipara contectoides	5.5		27.5	
Somatogyrus sp.	5.5		2.7	
Amnicola emarginata	1.1		trace	
Valvata spp.	7.7		0.4	
		148.6		61.2
Physa sp.	8.8		2.0	
Planorbis trivolvis	2.2		1.5	
Musculium transversum	53.3		26.6	
Pisidium sp.	70.0		28.0	
Oligochaeta (small spp.)	16.6		0.5	
Leeches (small spp.)	27.7		4.7	
Asellus sp.	6.6		0.6	
		76.3		7.9
Chironomid larvae (small)	7.7		1.0	
Agrionid nymph	15.5		0.6	
Coleopterous larvae	1.1		0.5	
Hyalella knickerbockeri	1.1		trace	
Total	232.6		99.2	

3 Channel Collections, July 28 and Aug. 19, 1915
Peoria Narrows

	Number per square yard		Pounds per acre	
Campeloma subsolidum	3.3		9.9	
Lioplax subcarinatus	0.6		0.7	
		23.2		46.3
Vivipara contectoides	3.3		16.5	
Pleurocera sp.	16.0		19.2	
Musculium transversum	1.0	1.0	0.5	0.5
Leeches (small spp.)	11.3		1.9	
		13.3		2.1
Caddis larvae (small spp.)	2.0		0.2	
Total	37.5		48.9	

4 Channel Collections, July 28 and Aug. 19, 1915
Lower Lake, Opposite Eagle Packet Landing

	Number per square yard		Pounds per acre	
Campeloma subsolidum	26.0		78.0	
Lioplax subcarinatus	37.0		44.4	
		134.7		391.6
Vivipara contectoides*	48.2		241.0	
Pleurocera species	23.5		28.2	
Musculium transversum	1.5		0.7	
		5.0		3.1
Sphaerium stamineum	3.5		2.4	
Oligochaeta (small spp.)	17.5		0.6	
Leeches (small spp.)	29.0	48.0	4.9	5.6
Caddis larvae (small spp.)	1.5		0.1	
Total	187.7		400.3	

* A small number of *V. subpurpurea* included.

4 Collections, 4- to 7-ft. Zone, July 26—27, 1915
Lower Lake, Opposite Eagle Packet Landing

	Number per square yard		Pounds per acre	
Campeloma subsolidum	18.5		55.5	
Lioplax subcarinatus	27.5		33.0	
		153.0		446.3
Vivipara contectoides	60.5		302.0	
Pleurocera sp.	46.5		55.8	
Amnicola emarginata	17.5		0.9	
Valvata spp.	53.0		26.5	
Musculium transversum	37.0	167.5	25.9	55.5
Sphaerium stamineum	20.0		0.8	
Pisidium species	40.0		1.4	
Leeches (small spp.)	22.5		3.8	
		52.5		5.8
Asellus sp.	15.0		1.4	
Hyalella knickerbockeri	15.0		0.6	
Total	373.0		507.6	

1 Collection, 1- to 3-ft. Zone, July 28, 1915
Lower Lake, Opposite Eagle Packet Landing

	Number per square yard		Pounds per acre	
Vivipara contectoides	30		150.0	
		50		174.0
Pleurocera sp.	20		24.0	
Planorbis trivolvis	10		7.0	
Pisidium sp.	30	70	1.2	9.8
Valvata spp.	30		1.6	
Hyalella knickerbockeri	100		4.0	
		120		7.4
Leeches (small spp.)	20		3.4	
Total	240		191.2	

2. Foot of Peoria Lake (Wesley) to Pekin

4 Channel Collections, July 22 and Aug. 19, 1915
Wesley to Pekin

	Number per square yard		Pounds per acre	
Campeloma subsolidum	49.0		147.0	
Lioplax subcarinatum	15.0	87.7	18.0	224.6
Vivipara subpurpurea	8.2		41.0	
Pleurocera sp.	15.5		18.6	
Musculium transversum	16.7	16.7	8.3	8.3
Leeches (small spp.)	61.5		10.4	
Chironomid larvae (small spp.)	50.0	129.0	7.0	20.9
Hydropsyche sp. (larva)	17.5		3.5	
Total	233.4		253.8	

4 Collections, 4- to 7-ft. Zone, Aug. 19, 1915
Wesley to Pekin

	Number per square yard		Pounds per acre	
Campeloma subsolidum	10.5		31.5	
Vivipara subpurpurea	4.5	20.0	22.5	60.0
Pleurocera species	5.0		6.0	
Musculium transversum	270.0	272.5	135.0	136.7
Sphaerium stamineum	2.5		1.7	
Leeches (small spp.)	55.0	56.5	9.3	9.6
Hydropsyche sp. (larva)	1.5		0.3	
Total	349.0		206.3	

3. Pekin to Copperas Creek Dam

14 Channel Collections, July 22, 23, 28, and Aug. 19, 1915
Pekin to Copperas Creek Dam

	Number per square yard		Pounds per acre	
Campeloma subsolidum	17.1		51.3	
Lioplax subcarinatus	2.6		3.1	
		28.8		73.3
Vivipara subpurpurea	2.1		10.5	
Pleurocera sp.	7.0		8.4	
Musculium transversum	126.7		63.3	
		126.9		63.7
Young Unionidae	0.2		0.4	
Leeches (small spp.)	42.0		7.1	
Chironomid larvae (small spp.)	6.4	49.8	0.8	8.1
Hydropsyche sp. (larva)	1.4		0.2	
Total	205.5		145.1	

9 Collections, 4- to 7-ft. Zone, July 22, 23, and Aug. 19, 1915
Pekin to Copperas Creek Dam

	Number per square yard		Pounds per acre	
Campeloma subsolidum	95.3		285.9	
Lioplax subcarinatus	8.8		10.5	
		177.6		638.0
Vivipara contectoides	66.7		333.5	
Pleurocera sp.	6.8		8.1	
Musculium transversum	102.6		51.3	
Young Unionidae	0.1	104.0	0.2	52.4
Planorbis trivolvis	1.3		0.9	
Leeches (small spp.)	23.8		4.0	
Chironomid larvae (small spp.)	4.0	34.4	0.5	5.1
Caddis larvae (small spp.)	6.6		0.6	
Total	316.0		695.5	

7 Collections, 1- to 3-ft. Zone, July 22, 23, 1915
Pekin to Copperas Creek Dam

	Number per square yard		Pounds per acre	
Campeloma subsolidum	92.8		278.4	
Lioplax subcarinatus	5.7		6.8	
		108.4		292.4
Vivipara contectoides	1.4		7.0	
Pleurocera sp.	8.5		10.2	
Musculium transversum	135.7	135.7	67.8	67.8
Leeches (large sp)	5.7		11.4	
Leeches (small spp.)	52.8		8.9	
Small oligochaetes	8.5		0.2	
Asellus sp.	17.1		1.6	
		116.8		31.2
Chironomid larvae (large spp.)	8.5		5.6	
Chironomid larvae (small spp.)	15.7		2.1	
Hydropsyche sp. (larva)	7.1		1.4	
Young crayfishes	1.4		Not valued	
Total	360.9		391.4	

4. Copperas Creek Dam to Havana

8 Channel Collections, Aug. 3, 19, 1915
Copperas Creek Dam to one Mile above Liverpool

	Number per square yard		Pounds per acre	
Campeloma subsolidum	161.7		485.1	
Lioplax subcarinatus	17.7		21.2	
Vivipara contectoides	63.8	263.4	319.0	874.2
Vivipara subpurpurea	6.5		32.5	
Pleurocera sp.	13.7		16.4	
Musculium transversum	0.3	0.3	0.1	0.1
Leeches (small spp.)	18.6		3.1	
Asellus sp.	7.2	28.3	0.6	4.0
Chironomid larvae (small spp.)	2.5		0.3	
Total	292.		878.3	

4 Collections, 4- to 7-ft. Zone, Aug. 19, 1915
Copperas Creek Dam to one Mile above Liverpool

	Number per square yard		Pounds per acre	
Campeloma subsolidum	160.5		446.7	
Lioplax subcarinatus	60.7		72.8	
Vivipara contectoides	50.0	302.2	250.0	814.3
Vivipara subpurpurea	2.0		10.0	
Pleurocera sp.	29.0		34.8	
Musculium transversum	1212.5	1212.5	606.2	606.2
Leeches (small spp.)	76.0		12.9	
		96.7		15.7
Chironomid larvae (small spp.)	20.7		2.8	
Total	1611.4		1436.2	

8 Channel Collections, July 31 and Aug. 3, 4, 1915
One Mile above Liverpool to Havana

	Number per square yard		Pounds per acre	
Campeloma subsolidum	280.0		840.0	
Lioplax subcarinatus	74.7		89.6	
		1294.0		5156.0
Vivipara contectoides*	815.6		4078.0	
Pleurocera sp.	123.7		148.4	
Amnicola emarginata	3.0	3.0	0.1	0.1
Leeches (small spp.)	106.7		18.1	
Asellus sp.	64.5	171.8	6.1	24.7
Hexagenia bilineata (nymph)	0.6		0.5	
Total	1468.8		5180.8	

* Including a few *V. subpurpurea.*

13 Collections, 4- to 7-ft. Zone, July 31 and Aug. 4, 1915
One Mile above Liverpool to Havana

	Number per square yard		Pounds per acre	
Campeloma subsolidum	48.8		164.4	
Lioplax subcarinatus	41.9		50.2	
		120.8		319.3
Vivipara contectoides	22.8		114.0	
Pleurocera sp.	7.3		8.7	
Planorbis trivolvis	0.4		0.2	
Musculium transversum	3496.9	3537.3	1748.5	1776.7
Sphaerium stamineum	40.0		28.0	
Leeches (small spp.)	131.6		22.3	
Asellus sp.	38.9	172.0	3.7	26.0
Hyalella knickerbockeri	1.5		trace	
Total	3830.1		2122.0	

6 Collections, 1- to 3-ft. Zone, July 31 and Aug. 4, 1915
One Mile above Liverpool to Havana

	Number per square yard		Pounds per acre	
Campeloma subsolidum	90.3		270.9	
Lioplax subcarinatus	19.0		22.8	
		230.6		887.6
Vivipara contectoides	118.0		590.0	
Pleurocera sp.	3.3		3.9	
Planorbis trivolvis	10.6		7.4	
Musculium transversum	26.3	38.5	13.1	21.6
Sphaerium stamineum	1.6		1.1	
Oligochaeta (small spp.)	6.6		0.2	
Leeches (small spp.)	36.1		6.1	
		81.0		10.5
Asellus sp.	25.0		2.4	
Chironomid larvae (small spp.)	13.3		1.8	
Total	350.1		919.7	

5. Havana to Lagrange Dam, 1915

16 Channel Collections, Aug. 2, 4, 5, 6, 27, 1915
Havana to Lagrange Dam (42.5 Miles)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	5.0		15.0	
Lioplax subcarinatus	0.33		0.3	
Vivipara contectoides and subpurpurea	0.12	5.57	0.6	16.0
Pleurocera sp.	0.12		0.1	
Musculium transversum	6.0	6.0	3.0	3.0
Small oligochaetes	0.33		0.1	
Small leeches	1.0		1.7	
Asellus sp.	1.0		trace	
		3.77		3.0
Hydropsyche larvae	1.2		0.2	
Hexagenia bilineata (nymph)	0.12		1.0	
Chironomid larvae (small spp.)	0.12		trace	
Total	15.34		22.0	

22 Collections, 4- to 7-ft. Zone, Aug. 2, 5, 6, 27, 1915
Havana to Lagrange Dam (42.5 Miles)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	48		144.0	
Lioplax subcarinatus	8		9.6	
Vivipara contectoides or subpurpurea	16	73	80.0	234.8
Pleurocera sp.	1		1.2	
Amnicola emarginata	4		0.1	
Musculium transversum	84	88	42.0	42.1
Small oligochaetes	9		0.3	
Small leeches	8		1.3	
Asellus sp.	1.5		0.1	
Hydropsyche larvae	7.6	31.1	1.5	5.7
Hexagenia, etc. (nymphs)	2.5		2.2	
Chironomid larvae (small spp.)	2.5		0.3	
Total	192.1		282.6	

20 Collections, 1- to 3-ft. Zone, Aug. 2, 5, 6, 1915
Havana to Lagrange Dam (42.5 Miles)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	32.0		96.0	
Lioplax subcarinatus	2.3		2.7	
Vivipara contectoides or subpurpurea	55.0	99.3	275.0	385.7
Pleurocera sp.	10.0		12.0	
Amnicola sp.	2.0		0.1	
Musculium transversum	89.0	91.0	44.5	44.6
Small oligochaetes	trace			
Small leeches	5.5		0.9	
Asellus sp.	trace			
Hydropsyche larvae	4.0	18.3	0.8	5.2
Hexagenia, etc. (nymphs)	3.0		2.7	
Chironomid larvae (small spp.)	5.8		0.8	
Total	208.6		435.5	

2 Channel Collections, Aug. 6, 1915
Foot of Grand Island to Browning
(9-mile section of narrow, deep channel)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	0.5	1.5	1.5	2.7
Pleurocera sp.	1.0		1.2	
Musculjum transversum	5.0	5.0	2.5	2.5
Chironomid larvae (small spp.)	1.0	6.0	trace	1.0
Hydropsyche larvae	5.0		1.0	
Total	12.5		6.2	

10 Collections, 4- to 7-ft. Zone, Aug. 6, 1915
Foot of Grand Island to Browning
(9-mile section of narrow, deep channel)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	71.7	92.4	215.1	307.9
Lioplax subcarinatus	1.6		1.9	
Vivipara contectoides	14.9		74.5	
Vivipara subpurpurea	3.0		15.0	
Pleurocera sp.	1.2		1.4	
Musculium transversum	106.4	106.4	53.2	53.2
Chironomid larvae (small spp.)	1.9	10.3	0.2	4.5
Hydropsyche larvae	0.5		0.1	
Hexagenia, etc. (nymphs)	4.0		3.6	
Leeches (small spp.)	3.9		0.6	
Total	209.1		365.6	

4 Collections, 1- to 3-ft. Zone, Aug. 6, 1915
Foot of Grand Island to Browning
(9-mile section of narrow, deep channel)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	46.2		138.6	
Lioplax subcarinatus	2.5	327.4	7.5	1516.0
Vivipara contectoides	272.5		1362.5	
Pleurocera sp.	6.2		7.4	
Musculium transversum	186.2	186.2	93.1	93.1
Hydropsyche larvae	3.7		0.7	
Chironomid larvae (small spp.)	3.7	26.1	0.5	4.3
Leeches (small spp.)	18.7		3.1	
Total	539.7		1613.4	

6. Lagrange Dam to Grafton

14 Collections (averaged), Aug. 11, 1915
Lagrange Dam to Florence

	Number per square yard		Pounds per acre	
Four channel collections	0.25		trace	
Two collections, 4- to 7- ft. zone				
Musculium transversum	115.		57.5	
Eight collections, 1- to 3-ft. zone				
Musculium transversum	15.6	16.3	7.8	9.2
Young Unionidae	0.7		1.4	
Small oligochaetes	1.2	2.2	trace	0.9
Hexagenia, etc. (nymphs)	1.0		0.9	
Total	18.5		10.1	

5 Channel Collections, Aug. 10, 1915
Valley City to Kampsville

	Number per square yard		Pounds per acre	
Vivipara subpurpurea	1.0	1.0	5.0	5.0
Musculium transversum	1.4	1.8	0.7	1.5
Young Unionidae	0.4		0.8	
Small oligochaetes	6.2	28.8	0.2	5.9
Planarians	2.0		trace	
Hydropsyche larvae	19.0		3.8	
Hexagenia, etc. (nymphs)	0.8		0.7	
Chironomid larvae (small spp.)	0.2		trace	
Perlid nymphs	0.2		0.2	
Gomphid nymphs	0.4		1.0	
Total	31.6		12.4	

17 Collections, 4- to 7-ft. Zone, Aug. 10, 1915
Valley City to Kampsville

	Number per square yard		Pounds per acre	
Campeloma subsolidum	0.2	0.2	0.6	0.6
Musculium transversum	12.6	14.6	6.3	10.3
Young Unionidae	2.0		4.0	
Small Oligochaeta	4.5	19.0	0.1	5.7
Small leeches	0.5		trace	
Planarians	1.0		trace	
Hydropsyche larvae	7.6		1.5	
Hexagenia, etc. (nymphs)	3.1		2.7	
Chironomid larvae (small spp.)	1.8		0.2	
Gomphid nymphs	0.5		1.2	
Total	33.8		16.6	

8 Collections, 1- to 3-ft. Zone, Aug. 10, 1915
Valley City to Kampsville

	Number per square yard		Pounds per acre	
Musculium transversum	4.8	4.8	2.4	2.4
Oligochaetes, small	3.0		0.1	
Hydropsyche larvae	2.2		0.4	
		11.4		5.1
Hexagenia, etc. (nymphs)	5.0		4.5	
Chironomid larvae (small spp.)	1.2		0.1	
Total	16.2		7.5	

7 Channel Collections, Aug. 12, 22, 23, 1915
Head of Diamond Island to Grafton

	Number per square yard		Pounds per acre	
Musculium transversum	2.0		1.0	
		2.8		2.6
Young Unionidae	0.8		1.6	
Chironomid larvae (small spp.)	0.4		trace	
Hexagenia, etc. (nymphs)	3.0		2.7	
Hydropsyche larvae	0.5	25.5	0.1	3.9
Gomphid nymphs	0.2		0.4	
Oligochaetes (small spp.)	21.4		0.7	
Total	28.3		6.5	

12 Collections, 4- to 7-ft. Zone, Aug. 12, 22, 23, 1915
Head of Diamond Island to Grafton

	Number per square yard		Pounds per acre	
Musculium transversum	4.4		2.2	
		5.7		4.8
Young Unionidae	1.3		2.6	
Chironomid larvae (small spp.)	1.4		0.2	
Corethra larvae	0.5		trace	
Hexagenia, etc. (nymphs)	5.5		4.9	
		11.3		5.5
Hydropsyche larvae	0.9		0.2	
Gomphid nymphs	0.1		0.1	
Oligochaetes (small spp.)	2.9		0.1	
Total	17.0		10.3	

12 Collections, 1- to 3-ft. Zone, Aug. 12, 22, 23, 1915
Head of Diamond Island to Grafton

	Number per square yard		Pounds per acre	
Campeloma subsolidum	0.1	0.1	0.3	0.3
Musculium transversum	6.3		3.1	
		7.9		6.3
Young Unionidae	1.6		3.2	
Chironomid larvae (small spp.)	1.6		0.2	
Corethra larvae	0.7		trace	
Hexagenia, etc. (nymphs)	23.2		20.8	
Caddis larvae ("stick")	0.1	29.3	trace	21.3
Gomphid nymphs	0.1		0.2	
Oligochaetes (small spp.)	3.2		0.1	
Leeches (small spp.)	0.4		trace	
Total	37.3		27.9	

II. Bottom Fauna of the Lakes of the Illinois Valley, Copperas Creek Dam to Lagrange, 1914—1915

1. Deeper, Bottom-Land Type (Clear–Mud, Liverpool, Thompson, Dogfish, Sangamon Bay)

Clear Lake, Sept. 1, 1915. Bottom Fauna
8 Collections, Depth, 8 to 8.5 ft. No Vegetation

	Number per square yard		Pounds per acre	
Campeloma subsolidum	1.2	3.9	3.6	17.1
Vivipara contectoides	2.7		13.5	
Musculium transversum	371.8	404.9	185.5	186.8
Pisidium sp.	33.1		1.3	
Leeches (small spp.)	16.0	37.7	2.7	11.7
Chironomid larvae (large spp.)	13.0		8.7	
Small Oligochaeta	8.7		0.3	
Total	446.5		215.6	

Clear–Mud Lake, Sept. 1, 1915. Bottom Fauna
12 Collections, Depth, 1 to 6 ft.
(Some vegetation at two shallow stations)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	8.4	27.7	25.2	121.7
Vivipara contectoides	19.3		96.5	
Musculium transversum	219.1	249.2	109.5	110.7
Pisidium sp.	30.0		1.2	
Musculium jayanum	0.1		trace	
Leeches (small spp.)	42.1	58.7	7.1	17.7
Chironomid larvae (large spp.)	15.8		10.5	
Chironomid larvae (small spp.)	0.8		0.1	
Total	335.6		250.1	

LIVERPOOL LAKE, SEPT. 1, 1915. BOTTOM FAUNA
6 COLLECTIONS, DEPTH, 6.5 TO 9.5 FT. NO VEGETATION

	Number per square yard		Pounds per acre	
Campeloma subsolidum	2.6	5.9	7.8	24.3
Vivipara contectoides	3.3		16.5	
Musculium transversum	191.6	222.3	95.5	96.7
Pisidium sp.	29.1		1.1	
Valvata spp.	1.6		0.1	
Leeches (small spp.)	20.6	47.2	3.4	21.2
Chironomid larvae (large spp.)	26.6		17.8	
Total	275.4		142.2	

LIVERPOOL LAKE, SEPT. 1, 1915. BOTTOM FAUNA
9 COLLECTIONS, DEPTH 1.5 TO 6 FT.
(Some vegetation at shallower stations)

	Number per square yard		Pounds per acre	
Vivipara contectoides	23.4	23.4	117.0	117.0
Musculium transversum	6.6	26.5	3.3	4.2
Pisidium sp.	10.0		0.4	
Valvata spp.	2.2		0.1	
Amnicola limosa	5.5		0.3	
A. emarginata	2.2		0.1	
Leeches (small spp.)	15.5	53.7	2.6	28.2
Chironomid larvae (large spp.)	38.2		25.6	
Total	103.6		149.4	

THOMPSON LAKE, AUG. 12—20, 1914. BOTTOM FAUNA
8 COLLECTIONS,* DEPTH, 7 TO 9 FT.
(No vegetation; all mud bottom)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	21.3		63.9	
Lioplax subcarinatus	10.5	31.8	12.6	76.5
Valvata spp.	470.6		25.8	
Musculium transversum	208.3	936.1	104.0	140.0
Pisidium sp.	257.2		10.2	
Small Oligochaeta	4.0		0.1	
Small leeches	23.5		3.9	
Chironomid larvae (large spp.)	123.7		82.4	
		212.0		94.2
Chironomid larvae (small spp.)	46.7		6.5	
Palpomyia larvae	3.1		0.2	
Caddis larvae	11.0		1.1	
Total	1179.9		310.7	

* All above "cut-road."

THOMPSON LAKE, AUG. 12—20, 1914. BOTTOM FAUNA
10 COLLECTIONS,* DEPTH, 1 TO 6 FT. NO VEGETATION
(Eight collections, mud bottom; two collections, sandy)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	83.0		249.0	
Lioplax subcarinatus	63.0	218.5	75.6	687.1
Vivipara contectoides	72.5		362.5	
Amnicola limosa	40.0		2.2	
A. emarginata	31.0		1.1	
Valvata spp.	362.0	954.5	19.9	80.3
Musculium transversum	79.0		39.5	
Pisidium sp.	442.5		17.6	
Small Oligochaeta	10.0		0.3	
Small leeches	72.0		12.2	
		295.0		135.8
Chironomid larvae (large spp.)	180.0		120.0	
Caddis larvae	33.0		3.3	
Total	1468		903.2	

* All north of "cut-road."

THOMPSON LAKE, AUG. 12—20, 1914. BOTTOM FAUNA
12 COLLECTIONS,* DEPTH, 1 TO 6 FT. ALL IN VEGETATION
(Eleven collections, mud bottom; one collection, sandy)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	28.7		86.1	
Lioplax subcarinatus	2.0	69.0	2.4	280.0
Vivipara contectoides	38.3		191.5	
Amnicola limosa	0.8		trace	
Valvata spp.	69.5		3.8	
		171.5		37.9
Musculium transversum	65.4		32.7	
Pisidium sp.	35.8		1.4	
Small leeches	9.5		1.6	
Planarians	2.5		trace	
Chironomid larvae (large spp.)	268.0		179.5	
		311.2		183.5
Chironomid larvae (small spp.)	2.5		0.3	
Caddis larvae	17.5		1.7	
Caenis nymphs	0.8		trace	
Hyalella knickerbockeri	10.4		0.4	
Total	551.7		501.4	

* All north of "cut-road."

THOMPSON LAKE,* AUG 12—20, 1914. BOTTOM FAUNA
4 COLLECTIONS, DEPTH, 2 TO 4 FT. ALL IN VEGETATION

	Number per square yard	Pounds per acre
Chironomid larvae (large spp.)	330	221.1
Small oligochaetes	30	1.1
Total	360	222.2

* Foot of lake, below "cut-road."

THOMPSON LAKE, AUG. 12—20, 1914. BOTTOM FAUNA
3 SAND-BOTTOM COLLECTIONS,* DEPTH, 1 TO 5 FT.
(Some vegetation)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	46.6		139.8	
Lioplax subcarinatus	23.3	121.5	27.9	425.7
Vivipara contectoides	51.6		258.0	
Valvata spp.	96.6		5.3	
Musculium transversum	55.0	301.6	27.5	38.8
Pisidium sp.	150.0		6.0	
Chironomid larvae (large spp.)	10.0		6.7	
Small leeches	18.3		3.1	
Caddis larvae	26.6		2.6	
		103.1		22.4
Caenis nymphs	3.3		0.2	
Large libellulid (nymphs)	3.3		8.2	
Hyalella knickerbockeri	41.6		1.6	
Total	526.2		486.9	

* All above cut-road. These three collections, arranged separately here, are also included in tables preceding.

THOMPSON LAKE, AUG. 28, 1915. BOTTOM FAUNA
8 COLLECTIONS,* DEPTH, 7 TO 9 FT. NO VEGETATION

	Number per square yard		Pounds per acre	
Campeloma subsolidum	23.0		69.0	
Lioplax subcarinatus	11.2	100.5	13.4	413.9
Vivipara contectoides	66.3		331.5	
Valvata spp.	54.7		3.0	
Musculium transversum	106.5		53.2	
		372.7		64.6
M. jayanum	trace			
Pisidium sp.	211.5		8.4	
Small leeches	27.0		4.5	
Small Oligochaeta	1.2		trace	
		48.7		18.1
Chironomid larvae (large spp.)	20.3		13.6	
Caddis larvae	0.2		trace	
Total	521.9		496.6	

* All above "cut-road."

THOMPSON LAKE, AUG. 28, 1915. BOTTOM FAUNA
7 COLLECTIONS,* DEPTH, 1 TO 6 FT.
(No vegetation; all mud bottom)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	32.7		98.1	
Lioplax subcarinatus	19.5	150.0	23.4	610.5
Vivipara contectoides	97.8		489.0	
Valvata spp.	43.5		2.3	
Musculium transversum	30.2		15.1	
		261.8		24.9
M. jayanum	trace			
Pisidium sp.	188.1		7.5	
Small leeches	19.5		3.3	
		32.9		12.2
Chironomid larvae (large spp.)	13.4		8.9	
Total	444.7		647.6	

* All above "cut-road."

THOMPSON LAKE, AUG. 28, 1915. BOTTOM FAUNA
7 COLLECTIONS,* DEPTH, 1 TO 6 FT. ALL IN VEGETATION
(Three collections, mud bottom; four collections, sand and mud)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	39.1		117.0	
Lioplax subcarinatus	9.5	76.0	11.4	265.4
Vivipara contectoides	27.4		137.0	
Amnicola limosa	42.8		2.3	
Valvata spp.	109.2		6.0	
Musculium transversum	11.5	240.6	5.7	17.0
Musculium jayanum	trace			
Pisidium	77.1		3.0	
Chironomid larvae (large spp.)	11.7		7.8	
Caddis larvae	2.1		0.2	
		55.7		14.5
Small leeches	37.7		6.4	
Planarians	4.2		0.1	
Total	372.3		296.9	

* All above "cut-road."

THOMPSON LAKE,* AUG. 28, 1915. BOTTOM FAUNA
5 COLLECTIONS, DEPTH, 2 TO 6 FT. ALL IN VEGETATION

	Number per square yard	Pounds per acre
Vivipara contectoides	157	785.0
Pisidium sp.	12	0.4
Small leeches	169	28.7
Total	338	814.1

* Foot of lake, below "cut-road."

THOMPSON LAKE, AUG. 28, 1915. BOTTOM FAUNA
4 SAND-AND-MUD BOTTOM COLLECTIONS,* DEPTH, 1 TO 6 FT.
(All in vegetation)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	31.5		94.5	
Vivipara contectoides	54.0	96.2	270.0	377.3
Lioplax subcarinatus	10.7		12.8	
Valvata spp.	118.7		6.5	
Amnicola limosa	50.0		2.7	
		243.9		14.6
Musculium transversum	5.2		2.6	
Pisidium sp.	70.0		2.8	
Small leeches	57.5		9.7	
Planarians	7.5		0.2	
		83.2		19.9
Chironomid larvae (large spp.)	14.5		9.7	
Caddis larvae	3.7		0.3	
Total	423.3		411.8	

* All above "cut-road." These four collections, averaged separately here, are also included in a preceding table.

Dogfish Lake, Aug. 18, 1914. Bottom Fauna
3 Collections, Depth, 6.5 to 7 ft. No Vegetation

	Number per square yard		Pounds per acre	
Vivipara contectoides	1.6	1.6	8.0	8.0
Musculium transversum	3.3		1.6	
Pisidium sp.	33.3	41.6	1.3	3.1
Valvata spp.	5.0		0.2	
Leeches (small spp.)	16.6		0.9	
		186.6		12.3
Chironomid larvae (large spp.)	170.0		11.4	
Total	229.8		23.4	

Dogfish Lake, Aug. 18, 1914. Bottom Fauna
5 Collections, Depth, 2 to 6 ft. All in Vegetation

	Number per square yard		Pounds per acre	
Vivipara contectoides	66.0		330.0	
		68.0		336.0
Campeloma subsolidum	2.0		6.0	
Musculium transversum	10.0		5.0	
Pisidium sp.	128.0		5.1	
Valvata spp.	160.0	302.0	8.8	19.1
Amnicola limosa	2.0		0.1	
Planorbis, small sp.	2.0		0.1	
Leeches (small spp.)	12.0		2.0	
Chironomid larvae (large spp.)	40.0		26.8	
Chironomid larvae (small spp.)	20.0	82.0	2.8	42.4
Small libellulid nymphs	2.0		10.0	
Caddis larvae	8.0		0.8	
Total	452.0		397.5	

Dogfish Lake, Aug. 31, 1915. Bottom Fauna
12 Collections, Depth, 7.5 to 8.5 ft. No Vegetation

	Number per square yard		Pounds per acre	
Vivipara contectoides	10.6		53.0	
Lioplax subcarinatus	5.0	18.3	6.0	67.1
Campeloma subsolidum	2.7		8.1	
Musculium transversum	10.5		5.2	
Pisidium sp.	74.5		2.9	
Valvata spp.	165.3		9.0	
		290.5		18.5
Amnicola emarginata	37.5		1.3	
Planorbis (small sp.)	1.6		0.1	
Physa (small sp.)	1.1		trace	
Leeches (small spp.)	38.8		6.5	
Chironomid larvae (large spp.)	88.0		58.9	
		155.0		66.4
Small Oligochaeta	11.6		0.4	
Hyalella knickerbockeri	16.6		0.6	
Total	463.8		152.0	

Dogfish Lake, Aug. 31, 1915. Bottom Fauna
3 Collections, Depth, 1 to 6 ft. Very Little Vegetation

	Number per square yard		Pounds per acre	
Pisidium sp.	33.3		1.3	
Valvata spp.	66.6	166.5	3.6	7.3
Amnicola emarginata	66.6		2.4	
Leeches (small spp.)	50.0		8.5	
Chironomid larvae (large spp.)	176.6	243.2	117.9	126.9
Small Oligochaeta	16.6		0.5	
Total	409.7		134.2	

SANGAMON BAY, SEPT. 8, 1915. BOTTOM FAUNA
8 COLLECTIONS, DEPTH, 6.5 TO 7.5 FT. NO VEGETATION

	Number per square yard		Pounds per acre	
Campeloma subsolidum	9.1		27.3	
Lioplax subcarinatus	13.7	24.3	16.4	51.2
Vivipara contectoides	1.5		7.5	
Musculium transversum	81.8		40.9	
		91.0		41.4
Valvata spp.	9.2		0.5	
Leeches (small spp.)	16.3		2.7	
Chironomid larvae (large spp.)	15.6		10.4	
		38.0		14.0
Caddis larvae	5.6		0.5	
Hexagenia nymphs	0.5		0.4	
Total	153.3		106.6	

SANGAMON BAY, SEPT. 8, 1915. BOTTOM FAUNA
4 COLLECTIONS, DEPTH, 1.5 TO 6 FT. NO VEGETATION

	Number per square yard		Pounds per acre	
Campeloma subsolidum	35.7		107.1	
Lioplax subcarinatus	12.7		15.2	
		54.9		145.3
Vivipara contectoides	4.0		20.0	
Pleurocera sp.	2.5		3.0	
Musculium transversum	217.5		108.7	
		232.5		109.5
Valvata spp.	15.0		0.8	
Leeches (small)	27.0		4.5	
Chironomid larvae (large spp.)	3.7		2.4	
Palpomyia larvae	0.7	45.4	trace	10.2
Caddis larvae	11.5		1.1	
Hexagenia, etc. (nymphs)	2.5		2.2	
Total	332.8		265.0	

2. Deep, Sand-Beach Type (Quiver, Matanzas)

Quiver Lake, Sept. 30 to October 12, 1914. Bottom Fauna
15 Collections, Depth, 7 to 12 ft. No Vegetation

	Number per square yard		Pounds per acre	
Campeloma subsolidum	58.2		174.6	
Lioplax subcarinatus	48.0		57.6	
Vivipara contectoides	462.0	745.5	2,310.0	2,754.6
Vivipara subpurpurea	trace			
Pleurocera sp.	177.3		212.4	
Amnicola emarginata	1.3			
Musculium jayanum	3.3		1.7	
Pisidium sp.	1.0	6.2	trace	2.9
Young Unionidae	0.6		1.2	
Chironomid larvae. (small spp.)	24.0		3.3	
Small leeches	52.6		8.9	
Large leeches	16.0		32.0	
Small Oligochaeta	54.0	161.1	1.8	47.5
Caddis larvae	2.6		0.2	
Agrionid nymph	0.6		0.3	
Asellus sp.	11.3		1.0	
Total	912.8		2,805.0	

QUIVER LAKE, SEPT. 30 TO OCTOBER 12, 1914. BOTTOM FAUNA
17 COLLECTIONS, DEPTH, 1 TO 6 FT.
(Most in vegetation)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	24.7		74.1	
Lioplax subcarinatus	11.1		13.3	
		85.1		329.7
Vivipara contectoides	48.2		241.0	
Pleurocera sp.	1.1		1.3	
Amnicola emarginata	42.3		1.5	
Amnicola limosa	8.2		0.4	
Valvata spp.	9.4		0.5	
Physa, small	7.6	124.0	1.7	33.4
Young Unionidae	6.3		12.6	
Musculium transversum	32.0		16.0	
Pisidium sp.	18.2		0.7	
Chironomid larvae, large red	1.7		1.1	
Chironomid larvae, small	31.7		4.4	
Palpomyia larvae	5.5		0.3	
Caddis larvae	0.5		trace	
Hexagenia nymph	0.5		0.4	
Agrionid nymph	1.1	127.9	0.5	25.2
Large libellulid nymph	1.6		4.0	
Small leeches	34.1		5.7	
Large leeches	3.5		7.0	
Small Oligochaeta	11.7		0.4	
Hyalella knickerbockeri	36.0		1.4	
Total	337.0		388.3	

QUIVER LAKE, AUG. 30, 1915. BOTTOM FAUNA
3 COLLECTIONS,* DEPTH, 7 TO 10 FT. NO VEGETATION

	Number per square yard		Pounds per acre	
Vivipara contectoides	160	160	800	800
Small leeches	8.6		1.4	
Caddis larvae	6.0	26.2	0.6	3.1
Asellus sp.	11.6		1.1	
Total	186.2		803.1	

* All opposite Bishop's.

Quiver Lake, Aug. 30, 1915. Bottom Fauna
14 Collections, Depth, 1 to 6 ft. Most with Vegetation

	Number per square yard		Pounds per acre	
Vivipara contectoides	7.1	7.1	35.5	35.5
Amnicola limosa	16.0	17.0	8.8	9.3
Musculium transversum	1.0		0.5	
Small leeches	11.9	190.3	2.0	113.9
Chironomid larvae (large spp.)	162.8		109.0	
Chironomid larvae (small spp.)	13.5		1.9	
Agrionid nymph	2.1		1.0	
Total	214.4		158.7	

Matanzas Lake, Sept. 4, 1915. Bottom Fauna
9 Collections, Depth, 6.5 to 8.5 ft. No Vegetation

	Number per square yard		Pounds per acre	
Musculium transversum	63.3	284.3	31.6	40.6
Pisidium sp.	206.6		8.2	
Valvata spp.	14.4		0.8	
Small Oligochaeta	4.4	58.4	0.1	18.0
Small leeches	30.7		5.2	
Chironomid larvae (large spp.)	18.6		12.4	
Palpomyia larvae	4.7		0.3	
Total	342.7		58.6	

MATANZAS LAKE, SEPT. 4, 1915. BOTTOM FAUNA
6 COLLECTIONS (IN CERATOPHYLLUM AND POTAMOGETON), DEPTH 2 TO 6 FT.
(Some vegetation at all stations)

	Number per square yard		Pounds per acre	
Campeloma subsolidum	5.0		15.0	
Pleurocera sp.	1.6	14.9	1.9	58.4
Vivipara contectoides	8.3		41.5	
Musculium transversum	15.0		7.5	
Pisidium sp.	48.3	66.6	1.9	9.6
Valvata spp.	3.3		0.2	
Leech, small	13.8		2.3	
Chironomid larvae (large spp.)	2.3		1.5	
		26.0		9.9
Hexagenia, etc. (nymphs)	6.6		5.9	
Caenis nymph	3.3		0.2	
Total	107.5		77.9	

3. SHALLOWER, WEEDY TYPE (FLAG, SEEPS, STEWART)

FLAG LAKE, OCT. 6, 1914. BOTTOM FAUNA
3 COLLECTIONS, DEPTH, 4 TO 5 FT. ALL IN VEGETATION

	Number per square yard		Pounds per acre	
Musculium transversum	6.6		3.3	
Pisidium sp.	93.3		3.7	
Valvata spp.	276.6	443.1	15.1	25.7
Amnicola limosa	20.0		1.1	
Physa, small sp.	46.6		2.5	
Leech, small sp.	33.3		5.6	
Chironomid larvae (large spp.)	33.3		22.1	
Chironomid larvae (small spp.)	110.0	186.5	15.4	45.2
Agrionid nymph	3.3		1.5	
Caddis larvae	6.6		0.6	
Total	629.6		70.9	

Flag Lake, Aug. 27—30, 1915. Bottom Fauna
15 Collections, Depth, 3.5 to 5 ft. Little Living Vegetation

	Number per square yard		Pounds per acre	
Vivipara contectoides	1.0	1.0	5.0	5.0
Leech, small	37.8		6.4	
Chironomid larvae (large spp.)	23.3	69.5	15.4	22.9
Chironomid larvae (small spp.)	8.4		1.1	
Total	70.5		27.9	

Seebs Lake, Oct. 13, 1914. Bottom Fauna
7 Collections, Depth, 2.5 to 5 ft. Some Vegetation

	Number per square yard		Pounds per acre	
Vivipara contectoides	2.8	2.8	14.0	14.0
Musculium transversum	8.5		4.2	
Pisidium sp.	57.1		2.3	
Valvata spp.	130.0		7.1	
		233.0		15.5
Amnicola limosa	27.5		1.5	
Amnicola emarginata	5.7		0.3	
Physa, small sp.	4.2		0.1	
Leeches (small spp.)	8.5		1.4	
Leeches (large spp.)	18.5		36.0	
Chironomid larvae (large spp.)	48.5		32.5	
Small Oligochaeta	480.0	702.5	16.8	94.5
Libellulid nymph (small sp.)	4.2		2.1	
Hyalella knickerbockeri	142.8		5.7	
Total	938.3		124.0	

SEEBS LAKE, SEPT. 4, 1915. BOTTOM FAUNA
8 COLLECTIONS, DEPTH, 2 TO 5.5 FT. LITTLE VEGETATION

	Number per square yard		Pounds per acre	
Vivipara contectoides	3.7	3.7	18.5	18.5
Valvata spp.	34.0	34.0	1.8	1.8
Leeches (small spp.)	24.2	26.5	4.1	5.6
Chironomid larvae (large spp.)	2.3		1.5	
Total	64.2		25.9	

STEWART LAKE, SEPT. 7, 1915. BOTTOM FAUNA
12 COLLECTIONS, DEPTH, 2 TO 5.5 FT. ALL IN VEGETATION

	Number per square yard		Pounds per acre	
Campeloma subsolidum	8.7	20.8	26.1	41.0
Lioplax subcarinatus	12.0		14.4	
Vivipara contectoides	0.1		0.5	
Musculium transversum	21.0	69.8	10.5	24.4
Musculium jayanum	3.5		1.9	
Pisidium sp.	7.8		0.3	
Valvata spp.	32.5		1.7	
Young unionid	5.0		10.0	
Small Oligochaeta	2.5	54.0	0.1	8.4
Leeches, small	36.0		6.1	
Chironomid larvae (large spp.)	1.6		1.0	
Chironomid larvae (small spp.)	6.6		0.9	
Palpomyia larvae	4.0		0.2	
Hyalella knickerbockeri	3.3		0.1	
Total	144.6		73.8	

4. Very Shallow, very Weedy Type (Duck, Dennis, Crane)

Duck—Dennis Lake, Oct. 2, 1914. Bottom Fauna
5 Collections, Depth, 2.5 to 4 ft. All in Vegetation

	Number per square yard		Pounds per acre	
Valvata spp.	188.0		10.3	
Physa, small sp.	6.0		1.3	
Amnicola limosa	8.0	216	0.4	12.4
A. emarginata	12.0		0.4	
Pisidium sp.	2.0		trace	
Small leeches	2.0		0.3	
Small Oligochaeta	12.0		0.4	
Chironomid larvae (large spp.)	106.0		71.0	
Chironomid larvae (small spp.)	72.0		10.0	
		276		97.9
Agrionid nymph	6.0		3.0	
Libellulid nymph	4.0		10.0	
Corixa, small sp.	12.0		0.8	
Hyalella knickerbockeri	62.0		2.4	
Total	492		110.3	

Crane Lake, Sept. 7, 1915. Bottom Fauna
5 Collections, Depth, 1 to 3.5 ft. Some Vegetation

	Number per square yard		Pounds per acre	
Campeloma subsolidum	14.0	14.0	42.0	42.0
Musculium transversum	28.0		14.0	
		34.0		14.3
Valvata spp.	6.0		0.3	
Chironomid larvae (small spp.)	6.0		0.8	
Leeches (small spp.)	26.0		4.4	
Chironomid larvae (large spp.)	4.0		2.6	
		78.0		22.7
Palpomyia larvae	16.0		1.1	
Hexagenia, etc. (nymphs)	14.0		12.6	
Caddis larvae	12.0		1.2	
Total	126.0		79.0	

5. Dead Timber and Brush Areas

Dead Timber and Brush Areas, Vicinity of Havana,* Aug. 18 to Oct. 16, 1914
Bottom Fauna
6 Collections, Depth, 1.5 to 4 ft. Some Vegetation

	Number per square yard		Pounds per acre	
Campeloma subsolidum	1.6		4.8	
		6.6		29.8
Vivipara contectoides	5.0		25.0	
Amnicola emarginata	45.0		1.6	
A. limosa	10.0		0.5	
Valvata spp.	531.6		29.2	
Physa, small sp.	6.6		1.5	
Planorbis trivolvis	1.6	724.5	1.1	87.1
Planorbis, small sp.	3.3		trace	
Young Unionidae	1.6		3.2	
Musculium transversum	98.2		49.0	
Pisidium sp.	26.6		1.0	
Chironomid larvae (large spp.)	40.0		26.8	
Chironomid larvae (small spp.)	61.6		8.6	
Palpomyia larvae	10.0		0.7	
Caddis larvae	3.3	269.8	0.3	44.0
Small leeches	13.3		2.2	
Small Oligochaeta	5.0		trace	
Hyalella knickerbockeri	136.6		5.4	
Total	1,000.9		160.9	

* Head Quiver Lake; head Dogfish Lake; ridge between Flag and Thompson lakes.

Dead Timber and Brush Areas, Vicinity of Havana,* Aug. 31 to Sept. 11, 1915.
Bottom Fauna
10 Collections, Depth, 1.5 to 3.5 ft. Some Vegetation

	Number per square yard		Pounds per acre	
Vivipara contectoides	33.5	33.5	167.5	167.5
Valvata spp.	13.0		0.7	
Small Planorbis sp.	1.0	15.0	0.1	1.3
Musculium jayanum	1.0		0.5	
Chironomid larvae (large spp.)	41.0		27.4	
Small leeches	37.0	78.0+	6.2	33.6+
Hyalella knickerbockeri	present			
Total	126.5+		202.4+	

* Head of Clear Lake; head of Dogfish Lake; ridge between Quiver and Dogfish lakes; ridge between Flag and Thompson lakes.

III. Weed Fauna, 1- to 4-Foot Zone, Lakes and Backwaters in Vicinity of Havana, 1914

Dead Timber Ridge between Flag and Thompson Lakes, Oct. 6, 1914, Opposite "Warner's Cut," in Ceratophyllum and Algae Weed Fauna, Upper 9 Inches (Depth, 2 ft.)

	No. per sq. yard	Pounds per acre	
Valvata spp.	22,500	1,347.5	
Amnicola limosa	4,500	209.0	
			2,164.0
Physa (small spp.)	1,500	82.5	
Planorbis trivolvis	750	525.0	
Chironomid larvae (small spp.)	750	52.5	
Pelocoris	270	256.5	429.0
Hyalella knickerbockeri	3,000	120.0	
Total	33,270	2,593.0	

Head of Flag Lake, Oct. 7, 1914, in Smartweed and Scirpus Weed Fauna, Upper 9 Inches (Depth, 1.5 ft.)

	No. per sq. yard	Pounds per acre	
Physa (small spp.)	3,750	206.2	
Amnicola limosa	1,500	57.0	
			481.4
Valvata spp.	150	8.2	
Planorbis trivolvis	300	210.0	
Chironomid larvae (small spp.)	4,500	315.0	
Agrionid nymphs	1,500	750.0	
Small libellulid nymphs	750	375.0	2,036.2
Pelocoris femoratus	375	356.2	
Hyalella knickerbockeri	6,000	240.0	
Total	18,825	2,517.6	

MIDDLE OF DUCK LAKE, OCT. 2, 1914, IN POTAMOGETON PECTINATUS
WEED FAUNA, UPPER 9 INCHES (DEPTH, 4 FT.)

	No. per sq. yard	Pounds per acre	
Valvata spp.	37,500	2,062.5	
Amnicola limosa	1,500	55.5	2,421.7
Planorbis trivolvis	375	262.5	
Physa (small spp.)	75	41.2	
Chironomid larvae (small spp.)	375	26.2	86.2
Hyalella knickerbockeri	1,500	60.0	
Total	41,325	2,507.9	

FOOT OF THOMPSON LAKE, WEST SIDE, AUG. 12, 1914, IN POTAMOGETON PECTINATUS
WEED FAUNA, UPPER 9 INCHES (DEPTH, 3.5 FT.)

	No. per sq. yard	Pounds per acre	
Physa (small spp.)	9,600	528.0	534.6
Planorbis (small spp.)	120	6.6	
Caenis nymphs	1,920	153.6	
Agrionid nymphs	2,400	1,200.0	1,953.6
Chironomid larvae (small spp.)	6,000	420.0	
Hyalella knickerbockeri	4,500	180.0	
Total	24,540	2,488.2	

Foot of Thompson Lake, East Side, Aug. 14, 1914, in Ceratophyllum, Smartweed, and Algae

Weed Fauna, Upper 9 Inches (Depth, 2.5 ft.)

	No. per sq. yard	Pounds per acre	
Physa (small spp.)	6,000	335.0	
Planorbis (small spp.)	240	13.2	
Planorbis trivolvis	600	420.0	991.4
Valvata spp.	2,400	132.0	
Amnicola limosa	2,400	91.2	
Pelocoris femoratus	240	228.0	
Small libellulid nymphs	1,200	600.0	
Agrionid nymphs	600	300.0	
			1,314.0
Caenis sp. (nymphs)	1,200	96.0	
Small green chironomid larvae	600	42.0	
Hyalella knickerbockeri	1,200	48.0	
Total	16,680	2,305.4	

Middle of Flag Lake, Oct. 6, 1914, in Potamogeton, Ceratophyllum, and Algae

Weed Fauna, Upper 9 Inches (Depth, 4 ft.)

	No. per sq. yard	Pounds per acre	
Amnicola limosa	13,125	498.5	
Physa (small spp.)	750	41.2	560.3
Valvata spp.	375	20.6	
Small libellulid nymphs	375	187.5	
Agrionid nymphs	450	225.0	
			705.0
Chironomid larvae (small spp.)	750	52.5	
Hyalella knickerbockeri	6,000	240.0	
	21,825	1,265.3	

FOOT OF THOMPSON LAKE, MIDDLE, AUG. 14, 1914, IN POTAMOGETON PECTINATUS
WEED FAUNA, UPPER 9 INCHES (DEPTH, 4.5 FT.)

	No. per sq. yard	Pounds per acre	
Amnicola limosa	6,000	228.0	
Physa (small spp.)	960	52.8	320.4
Valvata spp.	720	39.6	
Pelocoris femoratus	60	57.0	
Agrionid nymphs	480	240.0	
Caenis sp., nymphs	480	38.4	833.4
Chironomid larvae (small spp.)	600	402.0	
Hyalella knickerbockeri	2,400	96.0	
	11,700	1,153.8	

IV. Bottom and Weed Fauna, Littoral Zone of Glacial Lakes of Northeastern Illinois, 1916

1. BOTTOM FAUNA

DEEP LAKE, AUGUST—OCTOBER, 1916. BOTTOM FAUNA
7 COLLECTIONS, LITTORAL ZONE, 1 TO 7 FT. SOME VEGETATION

	Number per square yard		Pounds per acre	
Pisidium spp.	100.5		4.0	
Amnicolidae	254.5		13.9	
Valvatidae	53.2	496.2	2.9	39.8
Physa	66.0		3.6	
Planorbis	22.0		15.4	
Leeches, small spp.	12.5		2.1	
Chironomid larvae (small spp.)	59.6		8.3	
Caenis nymphs	3.0		0.2	
Hexagenia, etc. (nymphs)	47.0		42.3	
Caddis larvae (on Chara)	56.5		5.6	
Sand-case caddis larvae	91.0		18.2	
		510.7		169.0
Libellulid nymphs	22.0		11.0	
Agrionid nymphs	28.1		14.0	
Gomphid nymphs	12.5		42.5	
Pelocoris femorata	19.3		18.3	
Hyalella knickerbockeri	156.2		6.2	
Asellus sp.	3.0		0.3	
Total	1,006.9		208.8	

CEDAR LAKE, AUGUST—OCTOBER, 1916. BOTTOM FAUNA
24 COLLECTIONS, LITTORAL ZONE, 1 TO 7 FT. SOME VEGETATION

	Number per square yard		Pounds per acre	
Sphaerium striatinum	4.4		3.0	
Musculium transversum	11.0		5.5	
Pisidium spp.	24.2		0.9	
Amnicolidae	37.4		2.0	
		121.0		24.2
Valvatidae	22.0		1.2	
Physa spp.	11.0		2.5	
Planorbis	6.6		0.3	
Unionidae, young	4.4		8.8	
Oligochaeta (small spp.)	4.4		0.1	
Chironomid larvae (small spp.)	46.2		[illegible]	
Palpomyia larvae	1.1		0.[illegible]	
Polycentropus larvae	trace			
Sand-case caddis larvae	26.4		5.2	
Caddis larvae (on Chara)	41.8		4.1	
Misc. caddis larvae	19.8		1.9	
		430.1		135.6
Hexagenia, etc. (nymphs)	85.8		77.2	
Agrionid nymphs	17.6		8.8	
Libellulid nymphs	15.4		16.5	
Gomphid nymphs	2.2		7.4	
Beetles, small	11.0		0.7	
Hyalella knickerbockeri	143.0		5.7	
Asellus sp.	15.4		1.5	
Total	551.1		159.8	

LAKE ZURICH, AUGUST—OCTOBER, 1916. BOTTOM FAUNA
13 COLLECTIONS, LITTORAL ZONE, 1 TO 7 FT. SOME VEGETATION

	Number per square yard		Pounds per acre	
Campeloma subsolidum	3.3	3.3	9.9	9.9
Pisidium spp.	21.3		0.8	
Amnicolidae	84.5	190.3	4.6	10.0
Valvatidae	84.5		4.6	
Oligochaeta (small spp.)	3.3		0.2	
Leeches (small spp.)	6.6		1.1	
Chironomid larvae (small spp.)	94.6		13.2	
Palpomyia larvae	6.6		0.5	
Corethra larvae	13.4		0.5	
Sand-case caddis larvae	38.7	226.6	7.7	49.2
Polycentropus larvae	1.5		0.3	
Agrionid nymphs	1.5		0.7	
Sialis larvae	1.5		0.9	
Hexagenia, etc. (nymphs)	25.3		22.8	
Hyalella knickerbockeri	33.6		1.3	
Total	420.2		69.1	

CRYSTAL LAKE, AUGUST—OCTOBER, 1916. BOTTOM FAUNA
6 COLLECTIONS, LITTORAL ZONE, 1 TO 7 FT. SOME VEGETATION

	Number per square yard		Pounds per acre	
Amnicolidae	58.5		3.2	
Valvatidae	58.5		3.2	
		168.0		16.0
Planorbis sp.	47.5		2.6	
Unionidae, young	3.5		7.0	
Chironomid larvae (small spp.)	3.5		0.5	
Ceratopogon larvae	3.5		0.2	
Hexagenia, etc. (nymphs)	11.0		9.9	
Libellulid nymphs	3.5		1.7	
Gomphid nymphs	3.5	340.0	11.9	40.4
Agrionid nymphs	3.5		1.7	
Caddis larvae (on Chara)	3.5		0.4	
Sand-case caddis	11.0		2.2	
Hyalella knickerbockeri	297.0		11.9	
Total	508.0		56.4	

LONG LAKE, AUGUST—OCTOBER, 1916. BOTTOM FAUNA
6 COLLECTIONS, LITTORAL ZONE. 1 TO 7 FT. SOME VEGETATION

	Number per square yard		Pounds per acre	
Sphaerium sp.	3.5	3.5	1.7	1.7
Chironomid larvae (small spp.)	36.5		5.1	
Hexagenia, etc. (nymphs)	11.0		9.9	
Sand-case caddis larvae	80.5		16.1	
Caddis larvae (on Chara)	22.0	190.0	2.2	50.7
Sialis larvae	7.2		4.3	
Gomphid nymphs	3.5		11.9	
Hyalella knickerbockeri	29.3		1.2	
Total	193.5		52.4	

SAND LAKE, AUGUST—OCTOBER, 1916. BOTTOM FAUNA
10 COLLECTIONS, LITTORAL ZONE. 1 TO 5 FT. SOME VEGETATION

	Number per square yard		Pounds per acre	
Amnicolidae	2.2		0.1	
		11.0		0.6
Valvatidae	8.8		0.5	
Oligochaeta (small spp.)	2.2		0.1	
Chironomid larvae (small spp.)	13.2		1.8	
Sand-case caddis larvae	13.2	33.0	2.6	13.1
Agrionid nymphs	2.2		1.1	
Gomphid nymphs	2.2		7.5	
Total	44.0		13.7	

PISTAKEE LAKE, AUGUST—OCTOBER, 1916. BOTTOM FAUNA
29 COLLECTIONS, LITTORAL ZONE, 1 TO 7 FT. SOME VEGETATION

	Number per square yard		Pounds per acre	
Goniobasis sp.	18.0	18.0	10.82	10.82
Sphaerium sp.	5.9		2.9	
Pisidium sp.	53.7		2.1	
Amnicolidae	260.9		14.3	
Valvatidae	38.5	366.2	2.1	26.0
Physa spp.	4.4		0.2	
Planorbis spp.	0.6		trace	
Unionidae, young	2.2		4.4	
Oligochaeta (small spp.)	5.3		0.2	
Planarians	13.6		0.5	
Small leeches	67.3		11.4	
Chironomid larvae (small spp.)	49.9		6.9	
Sand-case caddis	16.5		3.3	
		383.3		42.6
Hexagenia, etc. (nymphs)	9.0		8.1	
Agrionid nymphs	4.4		2.2	
Sialis larvae	2.2		1.3	
Asellus sp.	2.2		0.2	
Hyalella knickerbockeri	212.9		8.5	
Total	767.5		79.6	

Fox Lake (Including Mineola Bay), August—October, 1916. Bottom Fauna
28 Collections, Littoral Zone, 1 to 7 ft. Some Vegetation

	Number per square yard		Pounds per acre	
Campeloma subsolidum	0.8	0.8	2.3	2.3
Musculium transversum	0.8		0.4	
Musculium jayanum	1.6		0.8	
Sphaerium sp.	0.8		0.4	
Pisidium sp.	5.5	40.6	0.2	3.6
Amnicolidae	25.1		1.4	
Valvatidae	4.6		0.3	
Physa spp.	2.2		0.1	
Oligochaeta (small spp.)	15.6		0.5	
Planarians	1.6		0.1	
Leeches (small spp.)	14.7		2.5	
Leeches (large spp.)	0.8		1.5	
Chironomid larvae (small spp.)	9.2		1.3	
Palpomyia larvae	0.8		0.1	
Sialis larvae	0.8	278.2	0.5	18.0
Caenis larvae	7.7		0.6	
Caddis larvae, misc.	0.8		0.1	
Agrionid nymphs	3.1		1.5	
Libellulid nymphs	0.8		0.4	
Asellus sp.	0.8		0.1	
Hyalella knickerbockeri	221.5		8.8	
Total	319.6		23.9	

2. Weed Fauna

Head of Pistakee Lake, August 17, 1916, in Ceratophyllum
Weed Fauna, Upper 9 Inches (Depth, 3.5 ft.)

	No. per sq. yard		Pounds per acre	
Amnicola limosa	1,440		54.7	
		1,920		81.1
Physa sp.	480		26.4	
Chironomid larvae (small spp.)	720		23.7	
Small beetle	120		6.	
Plea striata	120	58,080	8.4	2,330.1
Caddis sp. (basket case)	120		12.0	
Hyalella knickerbockeri	57,000		2,280.0	
	60,000		2,411.2	

North Side of Nippersink Lake, August 18, 1916, in Potamogeton and Ceratophyllum
Weed Fauna, Upper 9 Inches, (Depth, 3.5 ft.)

	No. per sq. yard		Pounds per acre	
Amnicola limosa	600		22.8	
		840		36.0
Physa spp.	240		13.2	
Chironomid larvae (small spp.)	2,880		95.0	
		22,080		863.0
Hyalella knickerbockeri	19,200		768.0	
Total	22,920		899.	

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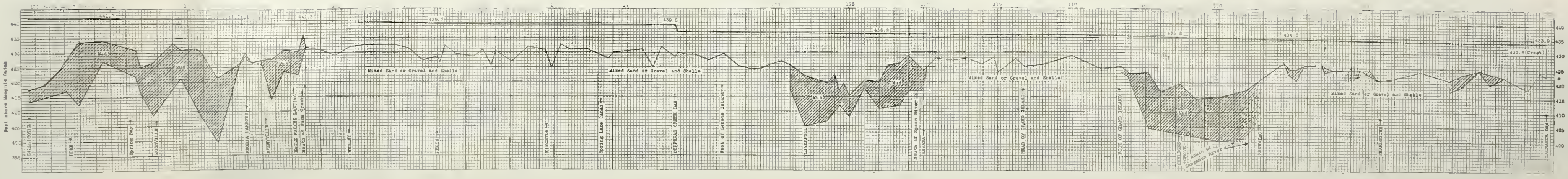
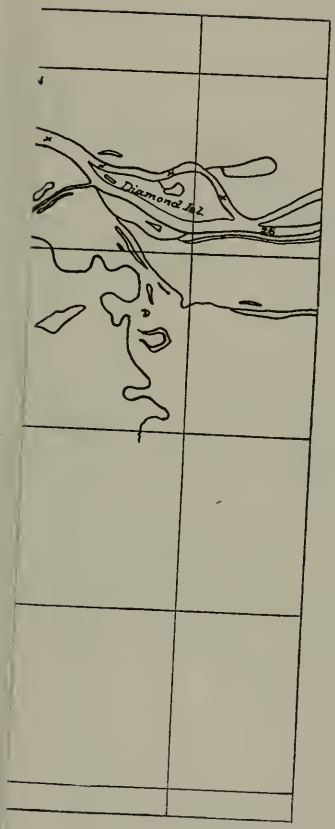
PROFILE OF A SECTION OF THE ILLINOIS RIVER

Profile of the Illinois River from Chillicothe to Lagrange dam, showing elevations of water surface at low gage of 1901, channel depths, and general character of upper layer of bottom soils and sediments. The profile marks out clearly the three deep, flat-sloped, mud-bottomed, natural pools in which the richest accumulations of small bottom-animals were found both in 1913 and 1915, viz.: the Peoria Lake pool, lying behind the great bar thrown up by Farm Creek; the Havana pool, behind the great natural wier formed by the wash from Spoon River; and the Sangamon pool, lying behind the high bar thrown up by the mouths of the Sangamon. The data here used (elevations, soundings, and borings) are from the report of the U. S. Engineers' Survey for a deep waterway, House Document No. 263, 59th Congress, 1st session, Washington, 1905.



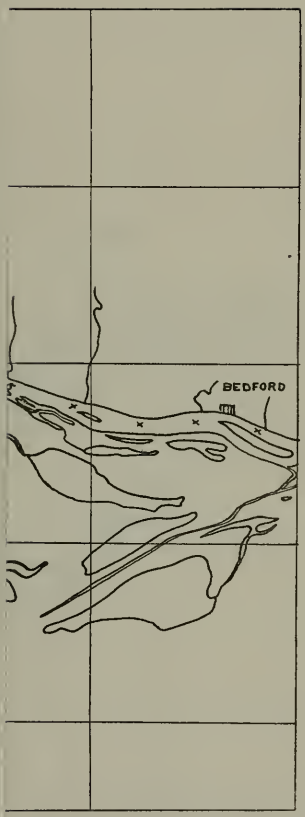
Feet above Memphis Datum
CHILLICOTHE
ROME
Spring Bay
MOSSVILLE
PEORIA NARROWS
AVERYVILLE
EAGLE PACKET LANDING
Mouth of Farm Creek
WESLEY
PEKIN
KINGSTON
Spring Lake Canal
COPPERAS CREEK DAM
Foot of Seneca Island
LIVERPOOL
Mouth of Spoon River
HAVANA
HEAD OF GRAND ISLAND
FOOT OF GRAND ISLAND
Mouth of Sangamon River
BEARDSTOWN
LAGRANGE DAM
Mud
Mixed Sand or Gravel and Shells
439.7
439.5
435.5
434.5
433.9
433.6 (Crest)

INDEX SHEET to the following maps of Illinois River and bottom-land lakes, Chillicothe to Grafton. (After U. S. Engineers' Survey, 1902–1905, House Doc. 263, 59th Congr., 1st Session, 1905.)



† For non-technical summary, see page 309.

1. Grafton sheet.



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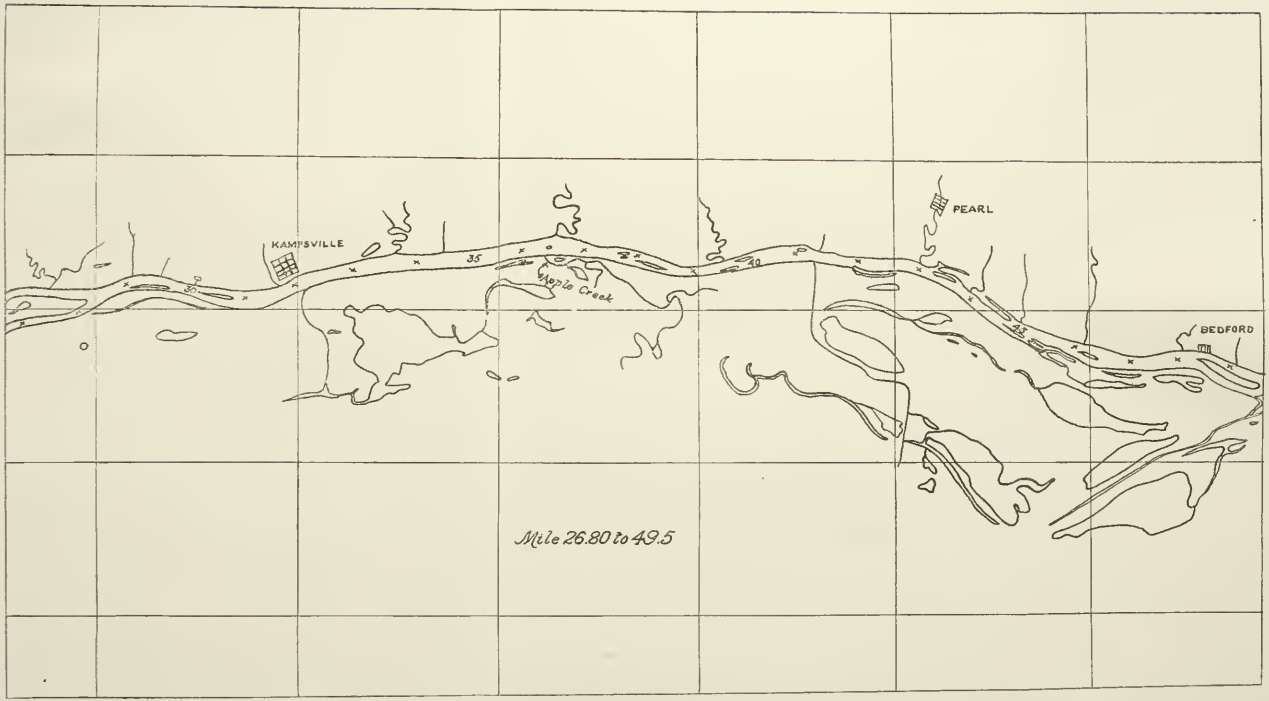
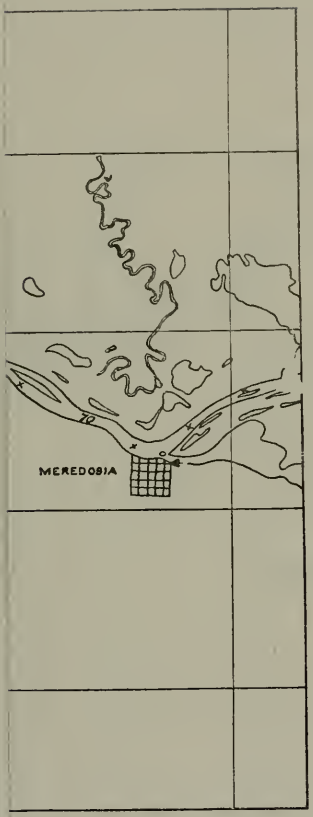


2. Kampsville sheet.



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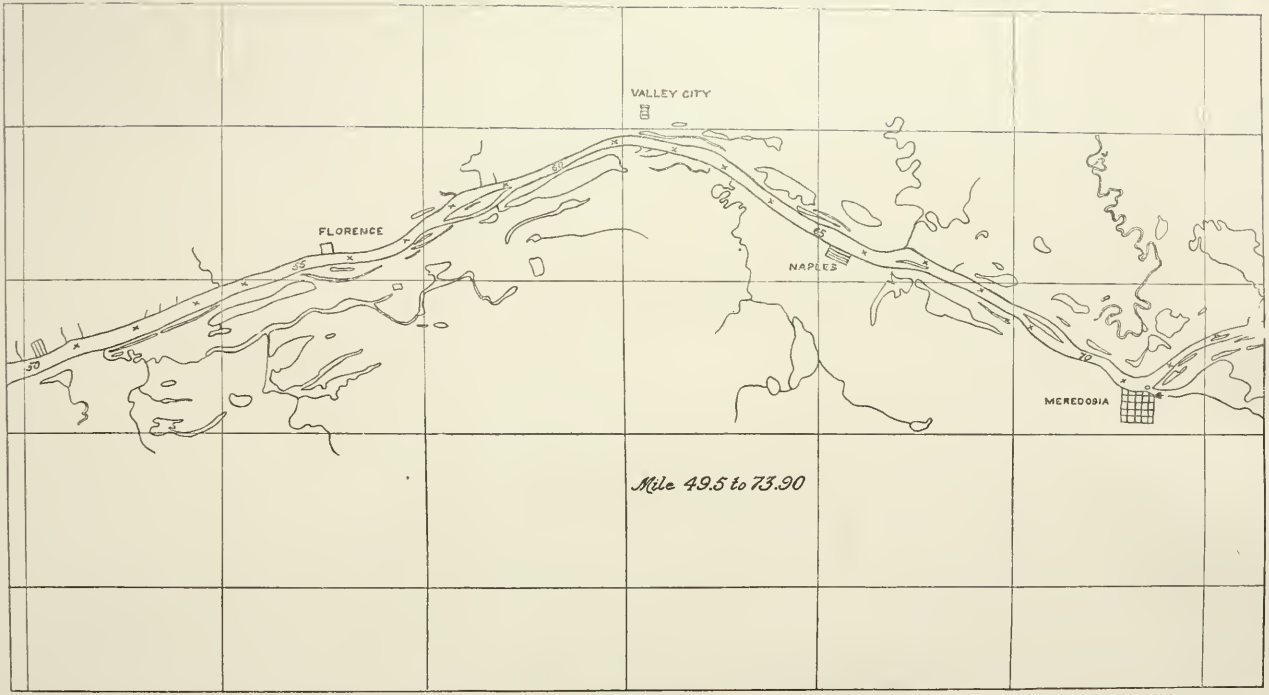
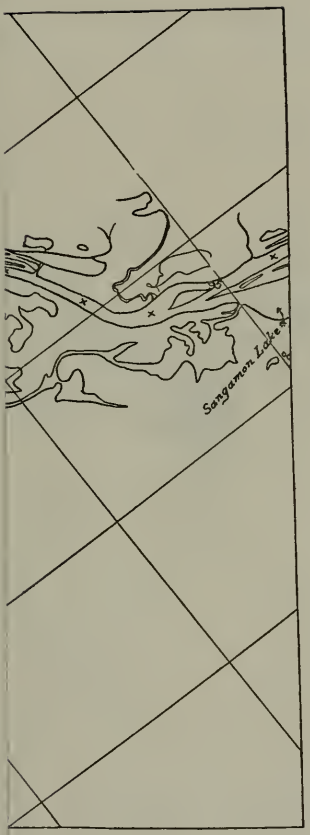


3. Meredosia sheet.



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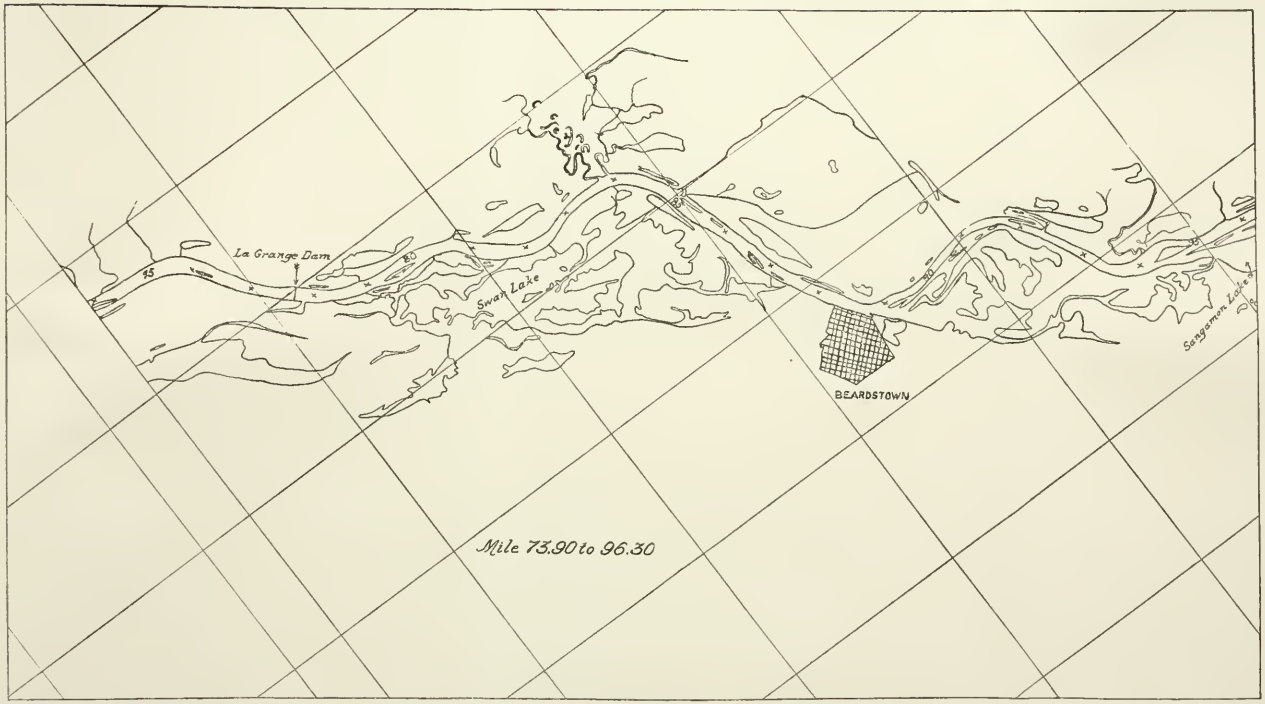
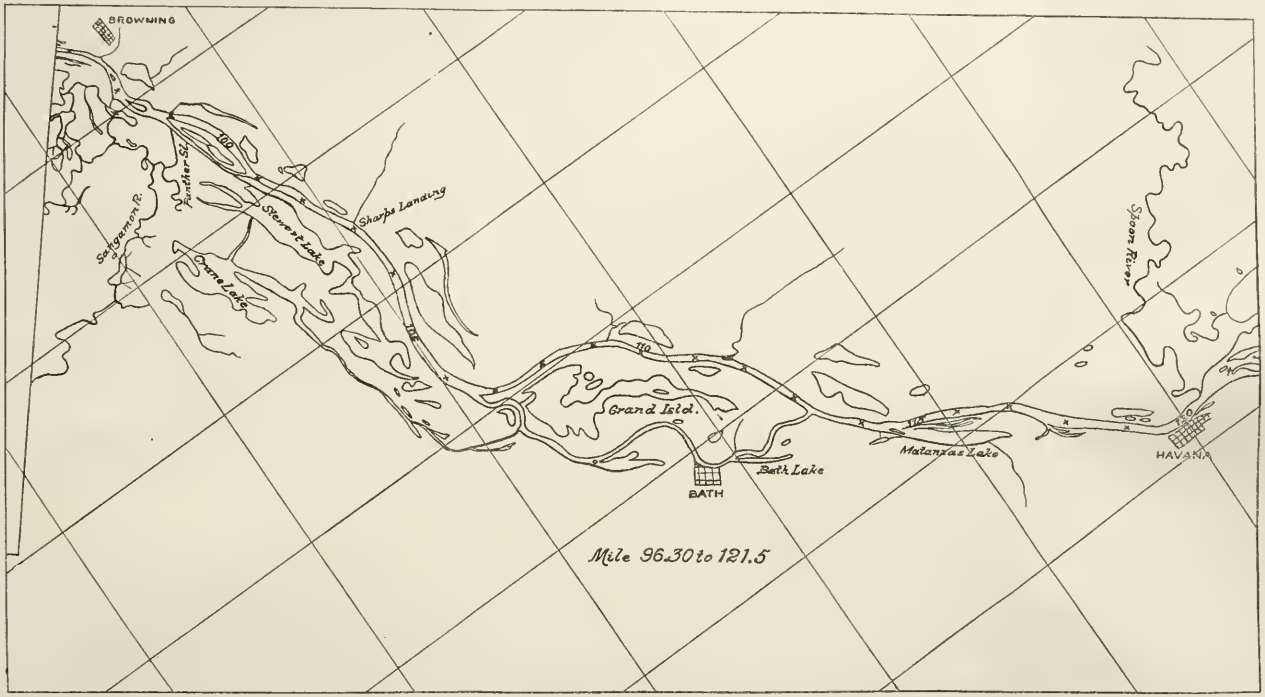


4. Beardstown sheet.

† For non-technical summary, see page



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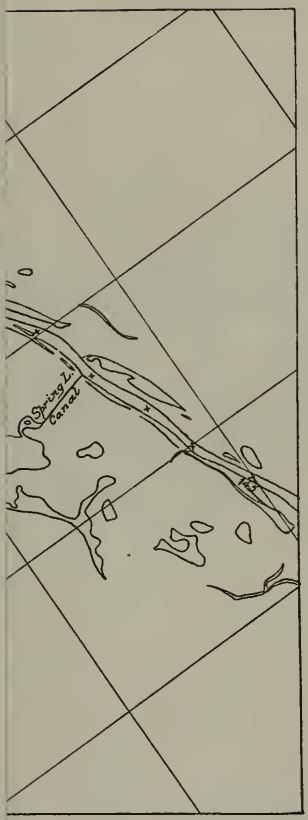

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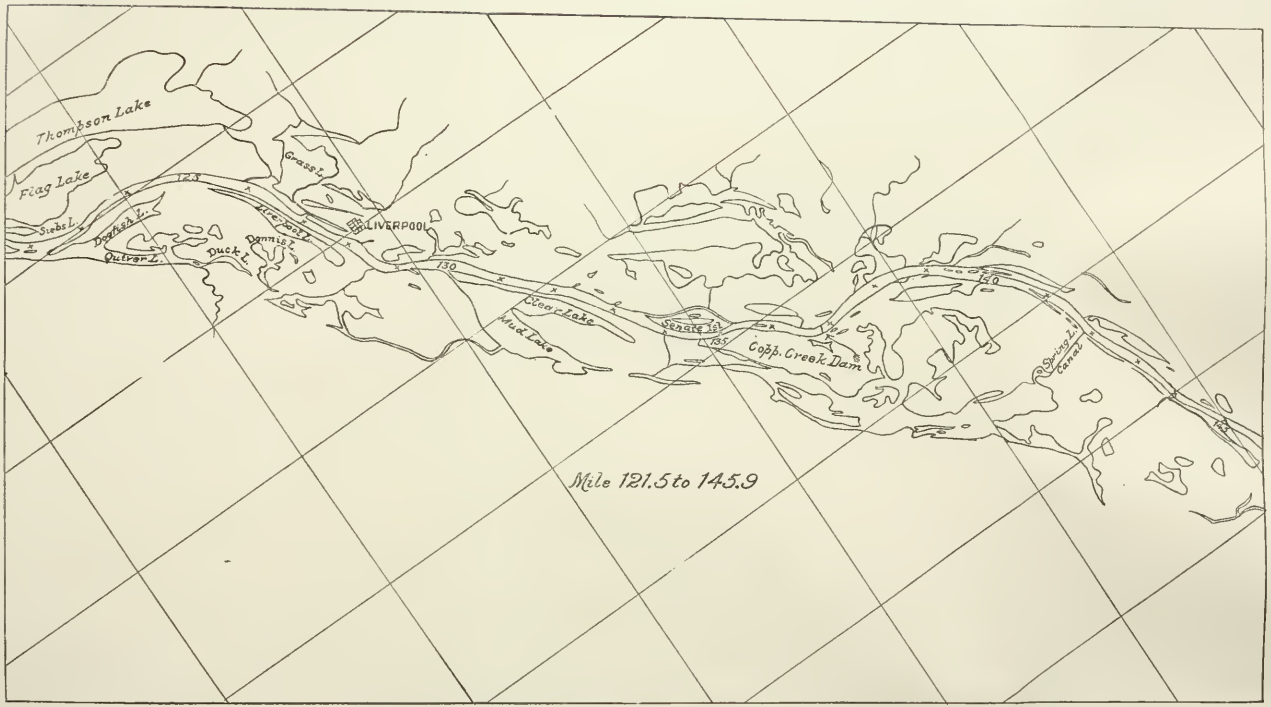
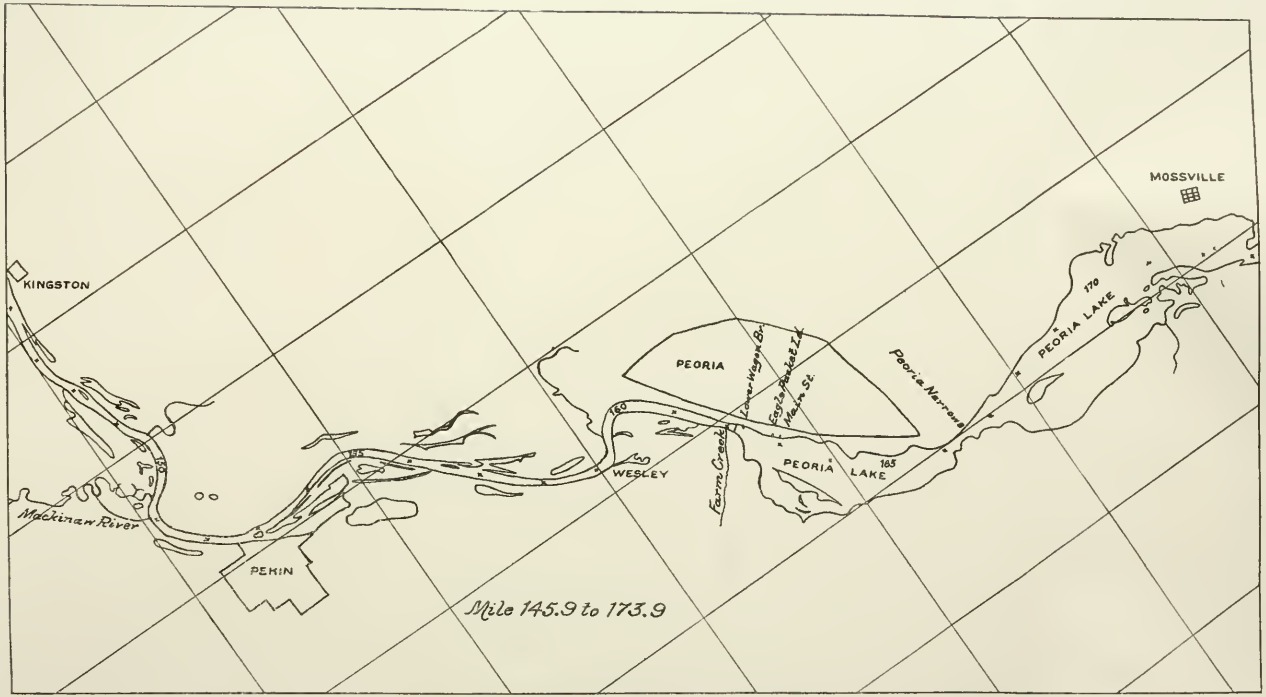
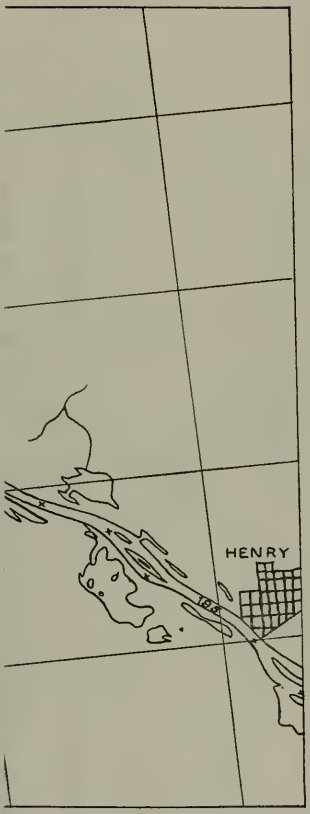


6. Liverpool sheet.

† For non-technical summary, see page 000.



7. Peoria sheet.



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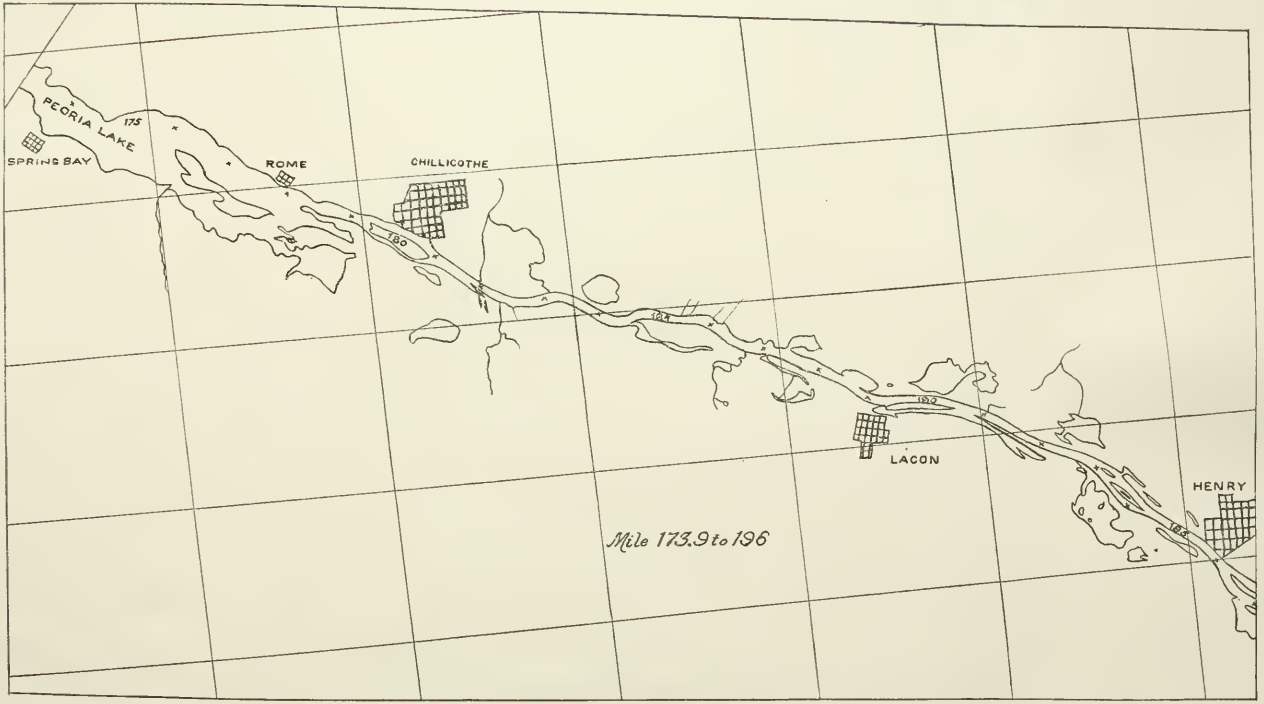

8. Chillicothe sheet.